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The Temperature of Meteorites

By CHARLES CLAYTON WYLIE

The temperature of meteorites at the instant of reaching the surface of the earth is a point on which scientific opinion is tending toward a very different view from that which the educated public in general still holds. The general view, formerly accepted in the best scientific circles, is that, since the meteor is seen in the upper atmosphere as a ball of fire, any meteorites which reach the earth should fall as balls of fire. Plate 11 of *Minerals from Earth and Sky*, Smithsonian Scientific Series, Volume III (1929), shows a trail of fire reaching from the sky to a point in a field toward which men are running. On page 65 of *Meteors, Aerolites, and Falling Stars*, by Phipson, one finds a similar illustration of a supposed meteoric fall. Most modern text-books fail to state definitely that this idea is not true, and undoubtedly the majority of those having had the elementary college courses in astronomy accept the general view, or something very similar.

The following, from *Fundamentals of Astronomy*, by Mitchell-Abbot, is one of the most definite text-book statements against the ball of fire idea: "Although the surface of the meteorite becomes very hot at its first entrance into the atmosphere, it is cooled again in the lower air. After it reaches the earth it is seldom hot enough to char wood, and often is merely a little warm to the touch." Olivier, in his recent book on meteors, is rather non-committal, writing—"Accounts differ most inexplicably as to the heat of the mass when first found"; but the opinion of some who have given the question the most study is illustrated by the following, from a personal letter, written in November, 1927, by the late Dr. George P. Merrill—"I find pretty conclusive evidence that the Dhurmsala stone, as well as those of Alfianello Italy, Colby Wisconsin, and Olivenz Spain, were cold when picked up immediately after falling. This is what one who has considered their source would naturally expect, and I am inclined to believe that reports to the contrary are based largely on the imagination. Of course, something may depend on the direction from which a meteorite comes—whether direct or otherwise—but stones are poor conductors of heat, and to my mind there is little probability of the correctness of the stories told in the newspapers and early literature. This applies to *stones* only. The irons may well be hot. The above represents my present view, and I am still gathering evidence." Farrington writes in *Meteorites*, pages 27-28, that stone meteorites are "milk warm" or "barely warm" if picked up immediately. Iron meteorites may be hotter, but even for these cases "any accounts, therefore, of intense heat displayed by meteorites can usually be assumed

to be false, the observer's previously formed opinion probably coloring his testimony if his testimony is sincere."

If the general view, that a meteorite reaches the earth as a ball of fire, is correct, a meteorite falling on a straw stack would set fire to it, and any grass adhering to the surface of a fallen stone would be charred. W. F. Denning, in an article on November meteors published in 1897, *Observatory*, Vol. 20, pages 307-308, includes two accounts of meteors setting fire to houses. A similar account is discussed in the Meteor Notes section of this issue of POPULAR ASTRONOMY. Such stories appear to have been formerly accepted without question. According to this view, more meteorites should be recovered from night falls than from those occurring in daylight, as a ball of fire attracts attention at a great distance by night, but by day would be noticed only by a person who happened to be looking in the right direction at the instant of the fall. An examination of Farrington's *Catalogue of Meteorites of North America* reveals that just the opposite is true. Out of 247 falls accepted as probably authentic, the date and hour of fall are given for 60 and, of the 60, nine were at night. One of these is a Central American fall in the year 1857, and the available information is very little. Another is listed as having possibly fallen in 1898 at Mariaville, Nebraska, but it is not included as a dated fall in Farrington's summary. Merrill includes it with the comment "perhaps doubtful."

The Saline meteorite, found in 1901, was believed by the finder to have fallen at the time he had observed a brilliant meteor nearly three years earlier. The account of this meteor reads:

"On the date mentioned (November 15, 1898) he was about to retire for the night when a great light seemed to flash in his house accompanied by a rushing noise. He supposed a large lamp in an adjoining room was exploding, but on hurrying to the room saw instead a great fiery mass passing the window near him. Its path was nearly horizontal and the direction of its motion northwesterly . . . The speed he estimated as one mile per second, the angle with the horizon as 25 degrees and that with the meridian as 20 degrees west of north . . . At the end of nearly three years, . . . his efforts were rewarded in the autumn of 1901 by finding the meteorite in the bank of a 'draw'." This was "about eight miles away."

The impression from reading this carefully is that it is a typical description of a brilliant meteor seen from a distance of about a hundred miles. The nearly horizontal path, low altitude, absence of bursting and detonations, and low estimate of velocity, all indicate that if any meteorites reached the earth at that time, they fell far from Saline. Farringon has written that "When a meteorite has been found it has customarily been referred to some meteor which someone remembers to have seen in the neighborhood at some previous time." In the month of November, 1929, two meteors, bright enough to be reported by persons outside of the state, were seen by residents of Iowa City apparently to fall northwest of the city. Meteors bright enough to cause shadows can

probably be seen northwest of Saline every two or three months, and the one from which this meteorite fell was almost certainly not the meteor observed on the evening of November 15, 1898. Merrill did not include this in his catalogue of observed meteoric falls. Three of the nine listed as night falls are therefore questionable, leaving six useful accounts.

NIGHT FALLS.

The account of the great fall near Amana, Iowa, (sometimes called the "Homestead" fall) on the night of February 12, 1875, includes the interesting statement that a seven-pound stone was found "precisely where observers had seen a 'glowing coal' descend to earth." The reference given to *Comptes Rendus* is not correct. The quotation is from an article in *Popular Science Monthly* by a professor in the University of Iowa, who tells us in a footnote that "The facts in regard to the meteor we have collected from the very full and reliable 'Account of the *Detonating Meteor of February 12, 1875*, by C. W. Irish'." An examination of the original accounts, by Irish and Leonard, disclosed that as the meteor burst, "glowing coals," or "sparks," were seen to fall toward the earth, but there is no suggestion that any of these were seen near the surface of the earth. There is conclusive evidence that the stones, seen immediately after bursting as "glowing coals," become non-luminous at an altitude of several miles. The detonations were heard more than a minute after the bursting and disappearance of the meteor, sparks and all. The noise of the falling stones was heard following the detonations, showing that they had been invisible for more than a minute. More than a hundred stones fell in a thickly settled community, and after the light and detonations had aroused every one. One stone fell within sixteen feet of a house; but no stones were found for three days, and only one before the melting of the snow several weeks later. In fact, from interviews with observers, Irish expected that the main meteoric field would be found fifteen or twenty miles north of where it proved to be located.

The accounts of the meteoric falls of Weston, Connecticut, and Modoc, Kansas, are similar. The communities were aroused by the light and detonations, and some of the stones were heard to strike, but none were seen, although in each case numerous meteorites were found afterwards. The Rochester meteorite was heard to strike, and found the next day. The first Bath Furnace meteorite was also recovered the morning following its fall by a family that heard it strike. A second stone was located later by a broken tree limb.

The Mazapil iron meteorite is the standard illustration of the meteorite found while hot, so it is worth while to examine carefully the letter of the ranchman on whose property it fell.

This was done on page 138 of Contribution No. 4 of the University of Iowa Observatory.* The letter states that soon after falling, the iron meteorite was hot, but not too hot to handle. At the instant of reaching

*POPULAR ASTRONOMY, **41**, 408.

the earth, the temperature must have been far below the boiling point of water.

An examination of accounts published after the completion of Farrington's catalogue discloses five additional falls reported to have occurred at night. For one of these, the recent fall near Paragould, Arkansas (Feb. 17, 1930, at 4:08 A.M.), the information is very detailed and we have an excellent illustration of the ease with which incorrect reports get into circulation. A newspaper feature begins as follows: "Just at dawn on a morning this spring people in the vicinity of Paragould, Arkansas, were awakened by a blinding light and deafening roar, followed by a loud report resembling a dynamite explosion . . . Awakened by the roar Mr. and Mrs. Fletcher got out of bed but could not stand up without holding on to something, their house trembled so violently. Then the Fletchers saw a large fiery object strike the earth not far from their home. When daylight came they went to the spot. They saw only a hole in the ground but clods of earth had been thrown as far as 100 yards. At the bottom of the hole 9 feet below the surrounding surface, they found a strange-looking rock. It was a meteor."

An investigator collecting information on the fall might well have received this clipping, and because of reference to a professor, assumed the story accurate. However, most of the account is incorrect. No one was found who was "awakened by a blinding light." Those asleep were first awakened by the "loud report resembling a dynamite explosion." The "deafening roar" was not "followed by" the "loud report." The roar followed the report instead of preceding it. The report perhaps did jar houses in the vicinity momentarily, but the trembling was all over before anyone in bed could get out. No one interviewed said that he "could not stand up without holding onto something." The Fletchers did not report that they "saw a large fiery object strike the earth not far from their home." They did not see the meteor at all, and from persons who did happen to be outdoors at the time, we can compute that the ball of fire appearance ended at a height of about five miles. The Fletchers did not go to the spot and make a search "when daylight came." The interest of the community in this fall was aroused by articles requesting information published in numerous newspapers in Arkansas and near-by Middle Western states, by letters written directly to residents of the community, and by personal visits. Mr. S. H. Perry purchased a smaller meteorite found on the day of the fall, and gave a public lecture. Numerous other persons visited the community to see the meteorite. This interested farmers in the community enough to put them on the lookout, and the hole made by the large meteorite was found on the Fletcher farm by a neighbor on March 16, not by one of the Fletchers on February 17, the morning of the fall.

From these reports of meteorites recovered from night falls it appears that there is no record of a meteorite having been seen to fall at night on the continent of North America. The meteors from which meteorites fall are very brilliant, and can be seen at a great distance, but

the meteorites are non-luminous in the lower atmosphere and invisible at night. There is evidence on the temperature immediately after falling in only two cases. The Mazapil iron meteorite was, as we have stated, reported quite hot, but not too hot to handle, when it was removed from the ground soon after it struck earth. One of the Amana meteorites, a stone, was found on the snow three days after the fall, and the snow adhering to the bottom of the stone indicated that a little was melted at the time of striking. This suggests that the stone was at a temperature above 32° F, but the stones in this fall were evidently not very warm, or enough snow would have been melted around each to make finding easy. The impact of striking would have melted some snow, even had the stone been a little below freezing. The fact that only one stone was recovered before, and more than a hundred after, the melting of the snow, shows that they did not melt an appreciable amount at the time of fall.

Day Falls.

The number of meteorites recovered from falls occurring in daylight is too great to permit of a full discussion such as we have given on the night falls. The first point noticed is that in several instances meteorites have actually been seen to fall by daylight, but they were not seen as balls of fire. They were seen as dark balls, or sometimes the falling meteorite was glimpsed for a moment as a dark streak. In several instances, although the stone itself was not seen, dust, snow or water was seen to fly where the meteorite struck, and this made possible a very quick recovery. In some instances, limbs of trees were seen to fall when struck, and more than one meteorite was heard to strike an out-building. A few meteorites not seen, although falling quite close to people, were located quickly by the thud of striking.

A careful examination of the reports on the temperature shows that where the locality was visited by a scientist, and the information obtained by careful personal interviews, the report is often that when found soon after striking, the meteorite was "milk warm" or "barely warm" or "still warm." For instance, the fall at New Concord, Ohio, was carefully investigated and the conclusion was that the meteorites were about as warm as stones lying in the sunshine. Some less complete reports, however, are to the effect that the meteorite was quite hot. The Allegan, Michigan, meteorite affords a good illustration of this type of report. It is stated that the sand around the meteorite was hot at a distance of two feet. This statement, however, does not agree with the fact that leaves on which the Allegan meteorite fell, and which were adhering to the surface, showed no effect of heat. We may add that in a number of other instances dry grass or other such material adhering to the surface of the meteorite has been examined, and one of the Forest City stones fell on a straw stack. In no case has any charring or any other effect of heat been noticeable.

In the letter previously quoted, Dr. Merrill gives four cases for which

he considered the evidence quite conclusive that the meteorite was cold when recovered immediately after falling. The Dhurmsala stone, which fell in India, is the standard illustration of the cold meteorite. One report is that it was covered with ice when dug up immediately after its fall. The Colby fall, also listed by Merrill, is another instance of extreme cold. These meteorites fell on a July afternoon, but one was reported cold enough to collect frost when dug up immediately after the fall. This report was verified by Dr. Farrington, who interviewed the finders personally. To Merrill's list we may add the fall at Tilden, Illinois, in July, 1927. These meteorites fell on a hot afternoon and one stone was literally seen to fall by two men who happened to be near when it struck. They went to the stone immediately and were surprised to find it not hot, but cold, "not like ice but noticeably cold." The men were interviewed separately by the writer, and others who handled the stone very soon after its recovery were interviewed. There is no doubt that it was distinctly cold as compard with rocks then in the sunshine. The dust was seen to fly where another of the Tilden meteorites struck, and a third stone was located by the thud of striking, but these were not dug up soon enough to offer definite evidence on the temperature question. Neither of these was at a temperature noticeably different from that of the surrounding earth.

Unauthenticated Accounts.

Investigators in this field become very insistent on complete accounts because of the number of ordinary rocks submitted for examination which, according to accounts, were seen to fall, and have set fire to grass, baked the surrounding clay, set fire to buildings, or charred and shrivelled the leaves of trees. The number of plausible and sincere letters accompanying such specimens causes scientists to be extremely skeptical of any information except that in complete and careful accounts.

As an illustration, let us take the following extract from the letter of a bank president on a supposed meteoric fall: "There is absolutely no question in my mind about this stone having fallen from the heavens. I examined the place where it fell, and saw the stones of the gutter that were driven into the ground, which could only have been brought about by this meteoric stone having fallen from a great distance. I also saw the tree through which the stone or meteor fell, and noticed that the tree showed evidences of having been charred, and the leaves shrivelled, proving that the meteor was red-hot when it fell.

"This meteorite fell during a big thunder storm and it was seen and heard by a great many people before it finally reached the earth. Many of my neighbors saw the great flash of light and heard the roaring sound of the falling mass."

The owner of this supposed meteorite (the bank president is not the owner) took it to Chicago for examination by the late Dr. O. C. Farrington of the Field Museum, who pronounced it not meteoric, but a

stone brought into the district during the ice age. The verdict of Farrington should be accepted; but there is no doubt that many people honestly believe that the stone is meteoric.

As another illustration, let us take a supposed meteoric fall in Nebraska. According to presumably honest letters submitted, the circumstances were that: On September 14, 1929, at 8:00 o'clock in the morning, a family living near Ingham, Nebraska, heard a roaring and hissing sound, and before they could get outdoors something struck the small frame house and shook it. The farm animals were frightened and when the family were able to get outdoors they found a white-hot stone which had set fire to the house. The small stone which, according to accounts, was recovered white hot, was sent to the University of Iowa for examination. A professor of geology reported that it was a "reddish, pinkish chert or flint in which are spots and flecks of white silica, which under magnification prove to be sections of crinoid stems and possibly other fossils. The specimen breaks with uneven conchoidal fracture. The unbroken surface is polished and pitted, apparently the result of wind abrasion by fine sand. It effervesces mildly with hydrochloric acid, proving that a part of the original lime is still present." If a meteoric stone did strike the house, it evidently was not the piece of flint recovered from the fire.

Theoretical Considerations.

A meteor in the atmosphere may be treated as a projectile moving in a resisting medium. Whatever the original direction of travel of the meteor, and whatever its original velocity, it approaches, as the surface of the earth is neared, a vertical fall and a velocity such that the resistance of the atmosphere is equal to the pull of gravity on the body. This is illustrated by Figure 148(a) on page 255 of MacMillan's *Theoretical Mechanics*. Professor F. R. Moulton gives the following as approximate values for the limiting velocity near the surface of the earth, assuming a smooth, spherical stone. For a one-inch meteorite the limit is two hundred feet per second; for one a foot in diameter the limit is seven hundred feet per second, and for a meteorite four feet in diameter the limit would be twelve hundred feet per second.

The stones actually observed to fall are all much less than four feet in diameter. In fact, few exceed one foot. For these the theoretical limiting velocity is well below the velocity of sound, in agreement with the observed fact that where the thud of the stone striking has been heard, this sound followed the blast of the explosion. It should be said that the thud of a stone striking can be heard only by a person very near the actual point of fall, and for most falls this sound has not been heard.

At these low velocities the resistance of the atmosphere would generate such a small amount of heat that it would be rapidly radiated and conducted away. For example, Professor Moulton calculated that if a body weighing five hundred pounds reached the earth with a speed of

four hundred feet per second the rate at which atmospheric resistance would be doing work would be less than sufficient to raise its temperature one degree per second if it had a specific heat of unity. Such a small amount of heat would be rapidly radiated and conducted away. These calculations agree with the observed fact that no meteorites have been seen to fall as balls of fire, and that where definite observations are available they indicate that the ball-of-fire appearance ended at a height of several miles. Evidently the velocity at that height was reduced to a point where the friction was not sufficient to heat it to the point of luminosity.

The temperature of a rotating black body at the distance of the earth from the sun, and in sunlight, is about 39° F. If the object were as good a reflector of the sun's radiation as the earth is, but emitted the long wave radiation well, the temperature would be several degrees below freezing. Probably the meteoroids,* immediately before entering the earth's atmosphere, are at a temperature not far from freezing. The surface of a stone in its flight through the upper atmosphere may be heated to a temperature approaching that of the sun, but the heating is only superficial. Stone is a poor conductor of heat, and the heated surface is continually being swept away by the rush of the air through which it is passing, and the ball-of-fire appearance lasts only a few seconds. Any stones which survive the disappearance of the meteor as a ball of fire quickly have their velocity reduced, as we have indicated, to a point where the heating effect of the resistance of the air to the fall is not appreciable. It seems reasonable, therefore, that on the average stone meteorites recovered immediately after striking would be a few degrees above freezing. The observed temperatures where the evidence is good appear to range from somewhat below freezing to about that of rocks lying in the sunshine on a summer afternoon, in good agreement with these theoretical considerations.

Iron is a good conductor of heat, and such meteorites would be heated more by the passage through the atmosphere. This agrees with the reports on the Mazapil and Cabin Creek iron meteorites, and on the Pits, which was largely iron. Few irons have been recovered immediately after falling, and the information is much less nearly complete than for stones.

These theoretical conclusions apply to any meteorites actually seen to fall, or recovered immediately after observation of the meteor. It is doubtful whether even the Cape York and Grootfontein meteorites reached the surface of the earth with a velocity sufficient to maintain luminosity.

Summary.

Where the information on a meteoric fall is reasonably complete, stone meteorites recovered immediately after falling are reported at tem-

*A meteoroid is a small solid body in interplanetary space. The fall of a meteoroid into the earth's atmosphere produces a meteor.

peratures from "milk warm" to below freezing, never really hot. Irons may be hotter, perhaps too hot to handle. Few meteorites, iron or stone, have been literally "seen to fall," and these were seen as dark bodies, not as balls of fire.

The general assumption that a meteorite falls as a ball of fire is regularly written into accounts of meteoric falls (as at Amana and Paragould), where investigation shows it is not correct. This makes investigators skeptical when such accounts are received. The cautious attitude of Farrington, Merrill, and others is further explained by the fact that stones quickly identified by geologists as common terrestrial rocks are regularly received with letters stating that they were picked up while still hot, or set fire to grass.

From theoretical considerations, we would expect an average temperature in good agreement with the reports from carefully investigated meteoric falls.

The Paragould meteor disappeared at an altitude of five miles. This furnished the largest meteorite "seen to fall" and it is probable that for nearly all smaller meteorites, the ball-of-fire appearance ends at a greater height.

UNIVERSITY OF IOWA, JANUARY 23, 1934.

Eras and Centuries

By ROSCOE LAMONT

In the *Boletin del Ejercito* (Army Bulletin) for June, 1926, published in Havana, Cuba, there is an article by an officer of the Cuban army on the subject: "When does a century begin and end?" The writer states that this has been the theme of a series of letters addressed to the editor of *El Mundo*.

It seems a little early to start such a discussion. Those whose memory can extend back a third of a century will recall that the subject was then widely discussed as to whether the twentieth century would begin on January 1, 1900, or on January 1, 1901. Germany, the papers reported, started ahead of other nations, beginning the century on January 1, 1900. Augustus De Morgan, in the *Companion to the British Almanac* for 1850, refers to a former controversy of the same nature, and, after quoting from De Morgan's article, some account will be given of this earlier controversy.

> "When a reckoning is made from 1, the century terminates at 100; but when it is made from 0, through 1, 2, etc., it terminates with 99. About the year 1799, there was discussion whether the eighteenth century terminated at the end of 1799, or at the end of 1800. This was equivalent to a discussion whether the usual reckoning had a year 0, or began with 1 . . . There is no ancient usage as to the beginning of centuries, for the term as applied to time is not ancient. Ducange and old Latin dictionaries do not recognize *centuria* as meaning a hundred years. The bull for the reformation of the calendar (1582), when speaking of 1700, 1800, etc., as

not being leap-years, calls them *anni centesimi, hundredth years.* But no argument can be derived in favour of an implication that technical centuries *end* with these years, for no such technical term seems to have been then in use . . . In the year 1800 Mr. Pye, then poet laureate, published his *Carmen Seculare,* with a preliminary dissertation in defence of 1800 being the first year of the new century. Among other arguments he urges that Prior had done the same in 1700 . . . We have looked through many of the pieces of this controversy, and have found little or no allusion to how people *did* count; the matter was assumed to demand settlement by the way in which people *ought* to count. Great pains were taken to prove that there must have been a year 0 after the Christian era; and those who could attribute the habits of a modern mathematician to the old computers—who reckoned I., II., III., IV., etc., and had never dreamed of a zero symbol—made a very plausible figure with those who could not correct them. The astronomers Maskelyne and William Herschel took the side of 1800 as the first year of the century, and of course led many, who did not see that the question is for the antiquarian to decide, not the astronomer, as such."

Mr. Pye, the poet laureate, whom De Morgan mentions, is a man whose fame, such as it was, has become dim. As the official poet of England, "every year on the king's birthday he produced an ode breathing the most irreproachable patriotic sentiment, expressed in language of ludicrous tameness. His earliest effort was so crowded with allusions to vocal groves and feathered choirs that George Steevens, on reading it, broke out into the lines:

'And when the *pie* was opened
The birds began to sing;
And wasn't that a dainty dish
To set before a king?'"[1]

Having made the acquaintance of Mr. Pye, it will be in order to quote a few passages from the preface to his *Carmen Seculare,* which is Latin for secular hymn.

"The controversy about the commencement of the nineteenth century, which has lately so much occupied the public mind, being of consequence to me, who am officially called on to give a public opinion on it, I very early turned my thoughts to the subject, and soon adopted the notion most generally received, that January 1, 1801, would be the first day of the nineteenth century. I found, however, all authority drawn from former precedents against me; I found that the Secular Masque of Dryden was performed at Drury-lane theatre early in the year 1700; and that Prior's Carmen Seculare was written for the same year, and obviously for the first of January. These examples were sufficient authority for me, independently of their showing the received opinion of that time. I found also in the schedule to the act of parliament for altering the style, and which is printed in all the Common Prayer Books, these words: 'for the next century, that is, from the year 1800 to the year 1899 inclusive.'

* * * * *

"A native of Scythia, Dionysius Exiguus, so named from his stature, who exercised the function of abbot at Rome in the sixth century, thinking it disgraceful that the Christians should reckon their years from the foundation of a city which was the seat of their persecutors, resolved to introduce a new era from the birth of Christ, which he fixed on December

[1] *Dictionary of National Biography,* Vol. 47, page 69. This may not be true. That nursery rhyme is 300 years old. Mr. Pye's first ode was for 1791, and it was published in the *Annual Register* of that year. There is no mention in it of any feathered singers.

25, in the year of Rome 753; but, to accommodate it to the Roman calendar, he reckoned from the first of January ensuing, in the manner that he exemplified by the following table of the first century, and on which the calculation of the beginning and close of the century just commenced in the table in our Common Prayer Books is founded:

0 1 2 3 4 5 6 7 8 9 10 etc.
* * * * *

"Having said this much in defense of myself and the authorities I follow, I beg leave to deprecate the resentment of those who are of a different opinion, for they are in general very warm in their cause. I do not positively insist that they are in the wrong; I only mean to show on what grounds, and on what authority I am in the wrong, should I happen to be so; a favor I have seldom had granted by those with whom I have argued *viva voce*."

Mr. Pye had no more favors granted him when writing down his opinions than when arguing *viva voce*. The critics were as harsh with him as Macaulay was with the next poet laureate, Mr. Southey, saying of him: "What he calls his opinions are in fact merely his tastes." Both prose and verse were poured out, and the Muse was called on to proclaim the truth, as in the following:

THE NEW CENTURY.

(In allusion to Mr. Pye's Odes and preface for the year 1800.)

"Spirit of truth," assist, inspire my lays,
To clear the town from doubt's uncertain maze:
Men who have drunk the Heliconian stream,
Men who have fathomed Learning's deepest mine,
Now boldly swear (most surely they must dream),
One Hundred Years are only Ninety-nine!
They also think it certain as the Sun,
A Year's complete the moment 'tis begun.
Much do I fear though, these sagacious men,
If owed eleven pounds would not take ten!
Suppose, too, they were traveling the road,
And had eight miles to reach their friend's abode.
They'd find the distance was not *wholly* gone,
The instant they had reached the seventh stone!
Oh! then, my Muse, devoid of dread or fear,
Proclaim this truth aloud
To all the listening crowd,
To-day *begins* a Century and a year!
And say, if asked the cause, the reason why?
Eighteen Hundred Years being now gone by,
'Tis evident and clear to Common Sense,
The Nineteenth Century must now commence.
Jan. 1, 1801.

Dionysius Exiguus, to whom Mr. Pye refers as the founder of the Christian era sometime in the sixth century, was a man of some importance. Mr. Pye's statement that he was called Exiguus because of his stature rests on no authority. Exiguus is a Latin word meaning little. It is not known whether Dionysius applied this term to himself because of his small stature, or whether it was because, like Mr. Heep, he was very umble. The French call him Denys le Petit.

It would be interesting to know where Mr. Pye found the series of numbers which he gives, 0, 1, 2, 3, 4, etc., by which, he says, Dionysius

exemplified the first century. Nothing like it is found in the writings of Dionysius as printed in Volume 67 of Migne's *Patrologia Latina*. No such figures were used in Dionysius' time, and a zero symbol was not heard of until centuries later. Somebody must have fooled Mr. Pye or else he was trying to fool others.

Dionysius makes no reference to the era of the foundation of Rome, as Mr. Pye has him do. There was in use in his time for reckoning the years what was called the Era of Diocletian, or Era of Martyrs, and it is this era that Dionysius mentions, and this is what he says, as translated by De Morgan, the passage referring to the Easter cycle of Cyrillus, containing ninety-five years, or five Metonic cycles of nineteen years each.

> "This cycle of ninety-five years we set ourselves to abolish by the attention to the subject with which we have gained the mastery over it; bringing forward in our own work the last, or fifth (Metonic) cycle of Cyrillus, because there are six years of it yet to run; and then we assert that we have arranged five other cycles according to the rule of the same prelate, or rather that of the Nicene Council often mentioned. But since Cyrillus began his first (Metonic) cycle from the 153rd year of Diocletian, and finished the last in the 247th year; we, beginning from the 248th year of that tyrant rather than prince, refuse to connect the memory of a blasphemer and persecutor with our cycles, but rather choose to note the dates of our years from the Incarnation of our Lord Jesus Christ."

Cyrillus' cycle ended with the 247th year of the Era of Diocletian, and Dionysius began his cycle with the following year—the 248th of Diocletian, and by calculation he found that this 248th year would be the 532nd year from the birth of Christ, and he designates his cycle accordingly, and begins it with that year. But Dionysius says, in the passage quoted above, that when he was writing there were six years of Cyrillus' cycle yet to run. The year after it expired he calls 532 anno domini. Then the year in which he was writing would be 525 A.D., and by his first rule he explains how he obtained it.

> "If you wish to know how many years there are from the Incarnation of our Lord Jesus Christ, compute 15 times 34 (quindecies XXXIV) which gives DX (510). Always add XII which makes DXXII. Add to this the indiction year, which is the third, and this makes DXXV (525). These are the years from the incarnation of the Lord."

An indiction cycle consisted of 15 years, and Dionysius considered that there had been 34 complete cycles since the birth of Christ, and 15 times 34 are 510. Three years of the cycle had passed at Christ's birth, and 12 years therefore remained of that first cycle, and by adding 12 to 510 he gets 522. The year in which he was writing was the third year of a cycle, and by adding 3 to 522 he obtains 525. The year 532 A.D. was the tenth year of the indiction cycle according to his table.

The solar cycle is a period of 28 years at the end of which the days of the month return to the same days of the week, by the Julian calendar, 28 years containing exactly 1461 weeks. The lunar or Metonic cycle is a period of 19 years after which the new and full moons occur again on the same day of the year. A combination of these two cycles,

28 times 19, gives 532 years, after the lapse of which the new and full moons return to the same day of the week and the same day of the month. As Easter depends upon the moon, "Denys le Petit took advantage of these properties to present the period of 532 years as being able to serve for the great Easter cycle."[2] And Denys, or Dionysius, was living at the very time, providentially he would say, when this Easter cycle of 532 years could be started at the year 532 A.D., as he reckoned.

It is believed by writers on chronology that a mistake was made of as much as four years, and that, if reckoned from the birth of Christ, the number of the year should be increased by 4,—instead of 1934 write 1938. That is why in tables of memorable dates, as in the World Almanac, the year of Christ's birth is given as 4 B.C.

Reginald L. Poole, in his interesting work "Medieval Reckonings of Time," (London, 1918) says of Dionysius:

> "He makes no suggestion that he is inventing a new era; he simply inserts the year calculated from one of the several slightly discrepant dates which were computed to indicate the year of our Lord's birth. And it never, in fact, became an Era until it was employed as a chronological note in English charters late in the seventh century, and was adopted by Bede in his 'Church History of the English Race.' The Year of Grace, therefore—to use the name familiar in England—is an English invention."

So the English invented it! Then they ought to have got it right. Bede got all his ideas from Dionysius and admits it.

But to come down to Mr. Pye's time. Those who held that the century began with the year 1800 made much of the language of the Act of Parliament of 1751, in the twenty-fourth year of George the Second, adopting the Pope's calendar. That was not an English invention. England eschewed it for 170 years, but finally swallowed it. The Archbishop of Canterbury said in 1583 that there was no use in adopting a new calendar, as the world would come to an end in a few years, and then they wouldn't need any calendar, certainly not the Pope's. The Act of Parliament contained the words: "For the next Century, that is, from the Year 1800 till the Year 1899, inclusive," and the Book of Common Prayer followed the language of Parliament.[3]

When Dr. Johnson had an interview with King George the Third in 1767, as reported by Boswell, the King urged him to continue his writing, and Johnson replied that he thought he had already done his share. "I should have thought so too," said the King, "if you had not written so well." When Johnson was asked if he made any reply to this compliment he answered: "No sir. When the King had said it, it was to be so." And when Parliament and the Prayer Book said that "the next century" would begin with 1800, those who believed in the om-

[2] Daremberg and Saglio, *Dictionary of Greek and Roman Antiquities*, Article, *Chronographia*. This is not absolutely correct as 19 Julian years do not contain an exact number of lunar months; the number is 235 and an hour and a half over. This excess of one and one-half hours in 19 years amounts to one day in 304 years, so a slight correction would be needed.

[3] The Act of Parliament was passed in 1751, to take effect in 1752.

nipotence of Church and State declared: "It is to be so." The next century was bound to come, and when it arrived, the Book of Common Prayer according to the use of the Protestant Episcopal Church in the United States of America, certified by the Bishop in the State of Pennsylvania, published in Philadelphia in 1812, stated: "For the present Century, that is, from the Year 1800 till the Year 1899, inclusive."

Because of the adoption of the Pope's calendar (it was all because of that), a change was made in 1800 in reckoning the dominical letter, continuing the same until 1899, and the Book of Common Prayer had to explain it, and Parliament, legislating for the Church, had to explain it too. And looking forward half a century, and seeing the figures change from 17 to 18, the Lords Spiritual and the Lords Temporal, and commoner people in the House of Commons, naturally thought the century changed at the same time, and so they wrote: "For the next Century, that is, from the Year 1800 till the Year 1899, inclusive." If the words had been, "For the period from the year 1800 till the year 1899, inclusive," the explanation would have been the same.

In the *Diary and Letters of Madame D'Arblay*, which Macaulay reviewed in the Edinburgh Review in 1843, in Chapter XXIV, dealing with events of the year 1786, there is a long account of a dispute at an evening party, which, Madame D'Arblay says, "brought forth much entertainment." It appears that Mrs. Delany was born in the year 1700, and the question in dispute was—In what century was Mrs. Delany born? Madame la Fite, a French lady, said it was clear enough to her that 1700 belonged to the last century, when Colonel Goldsworthy, surprised out of his glumness, exclaimed:

> "1700 belong to 1600! Why then I suppose Friday belongs to Thursday, and Wednesday to Tuesday! Bless us! here's such a set of new doctrines, a man won't know soon whether he's alive now or was alive in the last age!"

Mr. Pye would have agreed with the Colonel as to the century in which Mrs. Delany was born; and other names, very respectable ones too, are in the same class. The Astronomer Royal, Maskelyne, and Sir William Herschel, according to De Morgan's statement previously quoted, were in accord with Mr. Pye as to the time for the beginning of centuries. Peter the Great, by an Imperial Decree, changed the reckoning used in Russia, and the time for the beginning of the year, to conform to the practice of the other countries in Europe, and said: "The first of the coming January will conjointly begin the new year of 1700 and the new century." When the Czar had said it, it was to be so, at least in Russia. It had been the practice in Russia to begin the year on September 1, and to reckon from the creation of the world, counting 7208 years, and to exchange this figure for 1700, quite a recent date, savored too much of modernism to suit the Russian fundamentalists. But they were amazed, Voltaire says, to find that the Czar could change the course of the sun.

In Dr. Johnson's *Rasselas* the astronomer says: "I have possessed

for five years the regulation of the weather and the distribution of the seasons; the sun has listened to my dictates, and passed from tropic to tropic by my direction; the clouds, at my call, have poured their waters, and the Nile has overflowed at my command. What must have been the misery of half the globe if I had limited the clouds to particular regions, or confined the sun to either side of the equator?"

"Lyra will rise to-morrow," someone said to Cicero. "No doubt of it; there is an edict for it," he replied. The astronomers are a powerful lot. It was their practice until January 1, 1925, to begin the day at noon instead of at midnight. In the *Monthly Notices of the Royal Astronomical Society* for March, 1919, there is the following letter:

> Admiralty, 19th February 1919.
>
> Sir,—With reference to your letter of 21st December 1919, relative to the substitution in Nautical Publications of a day commencing at midnight for the Astronomical Day, I am commanded by My Lords Commissioners of the Admiralty to inform you that the Superintendent of the *Nautical Almanac* has been directed to make the alterations in the *Nautical Almanac*, commencing at the year 1925. I am, sir, your obedient Servant,
>
> J. W. S. ANDERSON.
>
> The Secretary,
> Royal Astronomical Society: Burlington House, W.

A letter from the British Admiralty changes the time for the beginning of the day. And note how farsighted the Admiralty is in this case, as always. A letter dated 19th February 1919 is in reply to one of the 21st December 1919, more than ten months later.

The *Encyclopedia Britannica*, in the article on *Chronology*, says that astronomers make use of a year 0. They can do anything. When some persons made use of a year 0 to prove that a century began when 1800 was first written, they were called ciphers. Mr. Pye's idea seemed to be something like this: There are two kinds of numbers, cardinal and ordinal, the cardinal numbers being one, two, three, etc., and the ordinals, first, second, third, etc. A person's age is expressed by cardinal numbers: 50 yrs., 8 mos., 24 days. An infant's age might be written, 0 yrs., 2 mos., 12 days. The time as shown by a watch is expressed by cardinal numbers: 3 hrs., 25 min., 15 sec. So, following this system, he thought the number 1800 would not be written until 1800 years had passed, just as 1800 miles are traveled before the milestone marked 1800 is reached, or before the figure 1800 appears on the speedometer. Then the 1801st year began, the number 1800 being written in dates to indicate the number of years elapsed, the progress into the next year being shown by the months and days.

If anyone wished to interpret dates in that way, there was no Act of Parliament against it. Mr. Pye's opinion was that there was an Act of Parliament for it. Every person is at liberty to assign such meaning to words or to figures as he sees fit until there is a constiutional amendment prohibiting it. While the intention of Dionysius seems clear enough in his computation of the year 525 A.D., the intention of a monk

who lived 1400 years ago cannot limit the freedom of action of people today. There is but little known with any certainty as to the way in which the Christian era was gradually adopted from the seventh to the tenth century. It never at any time represented the correct number of years from the birth of Christ. A mistake of four years is conceded by all chronologers; the *Encyclopedia Britannica* makes the mistake to be six years. While this mistake has nothing to do with the question at issue, yet Mr. Pye's method makes one year more than does the other method, and hence, whatever the mistake, lessens it by one year. And there is nothing to the statement that Mr. Pye made a century to consist of but ninety-nine years. Every one of Mr. Pye's centuries had a full one hundred years, just as every one of his twenty odes celebrating the birthday of King George the Third was one hundred percent patriotic; and the statement is made after reading the odes, it may be the only time in more than a hundred years a person has had the courage to do it. But, nevertheless, Mr. Pye's way does not seem to be the natural way, or the way in which an era would be established today.

Supposing the months to remain as at present, if an era were to be established now, the first day would naturally be written, January 1st, 1st year; the beginning of the hundredth year, January 1st, 100th year. There could be no misunderstanding, and the beginning of the second century would be January 1st, 101st year. If the word year is omitted, and also the letters after the numbers, writing, for example, February 6, 128, the numbers 6 and 128 still remain ordinal numbers. In the English statutes the dates of enactment are given as 27 Hen. 8, 5 Eliz., 49 Geo. 3, which means the twenty-seventh year of Henry the Eighth, the fifth year of Elizabeth, the forty-ninth year of George the Third. To use Mr. Pye's system it would be necessary to begin differently, as January 1st, 0 year (the 0 simply meaning that a year has not elapsed); January 1st, 1 year (meaning that 1 year has elapsed and the second year is beginning), and so on, as March 4, 250. But who would know, without a book of instructions, that the era had been started in such a way, and that 250 was a cardinal number indicating that 250 complete years had elapsed since the beginning of the era, the progress into the 251st year being shown by the month and day of the month, both ordinal?

At the time of the French Revolution the Gregorian calendar was abolished and an entirely new calendar made. A new era was established, for they declared: "No longer can we count the years when kings oppressed us as a time in which we have lived." The day of the autumnal equinox, happening September 22, 1792, by the old calendar, was the first day of the new era, and the year was marked with the Roman numeral I, although the calendar was not completed until the following year, the first year having elapsed before the new order of things was set going. Nevertheless, at the beginning of the second year the Roman numeral II was used, and the years following, at their commencement, were numbered III, IV, V, etc. Had this era, which

was meant to be everlasting and which lasted for thirteen years, continued for a hundred years, the hundredth year would have been marked C, and at the beginning of the second century the number CI would have been written. If the Arabic numbers had been used instead of the Roman it would have made no difference.

Charles Knight says in his book, "Passages of a Working Life during Half a Century," that on the night of the thirty-first of December, 1800, he went to bed with a vague fear that he should be awakened by a terrific noise, "not so much to welcome the coming of the new year and beginning of the new century (for the learned had settled, after a vast deal of popular controversy, that the century had its beginning on the 1st of January, 1801, and not on the 1st of January, 1800), but to hail the legal commencement of the Union with Ireland." A Union with Ireland, and other unions as well, are productive of terrific noises. And questions are rarely settled beyond discussion; and when the present century is nearing its end, some poet laureate, in looking over some unused books in his library, perhaps a Book of Common Prayer, may see the words of the Act of Parliament of 1751 adopting the Pope's calendar; and emulating Mr. Pye, he may write a *Carmen Seculare*, with a preliminary essay designed to prove that when the year 2000 comes to be written, twenty centuries will have passed, and celebrate in laureate verse the arrival of the twenty-first century.

WASHINGTON, D. C.

Note on the Theory of Tidal Evolution

By JOSEF J. JOHNSON

Many objections have been raised against the theory of tidal evolution as first proposed by Sir George Darwin. Poincaré, for instance, criticized on mathematical grounds the assumed fission of the "pear-shaped" or "cucumber-shaped" figure into two separate bodies. Chamberlain and Moulton and others have proposed theories of the origin of the solar system which obviate the necessity of assuming that the moon was once a part of the earth. Harold Jeffreys, perhaps the last able protagonist of the theory, has recently abandoned it as an explanation of the origin of the earth-moon system. But all objections, so far as the writer is aware, have to do with the past history of the system. Darwin clearly foresaw the possibilities in this direction when, shortly before his death, he remarked in reference to the fission theory of the moon's origin: ". . . it is only a wild speculation, incapable of verification." But the validity of the tidal theory as a whole is in no way dependent upon this speculation. Darwin rightly pointed out that, whatever the origin of the earth-moon system, tidal friction must begin to act once the system is formed, and that furthermore a consideration of the effects of tidal friction should enable us to forecast with great confidence

those slow changes which will modify the system during the enormous reaches of future time. It is here proposed to examine critically one point pertaining to the future course of the earth's rotation.

Tidal friction presumably acts as a brake upon the earth, gradually diminishing the rate of rotation. The reaction upon the moon tends to shove that body ahead in its orbit; the long-time result of this process is to increase the moon's mean distance from the earth. Thus the day and the month are both being lengthened, the day more rapidly. Darwin estimated that when in the far-distant future they finally become equal, they will each amount to 55 of our present days.[1] This event will mark the moon's all-time apogee. Subsequently the friction of solar tides will gradually decrease the angular momentum of the earth-moon system. Slowly the moon will be drawn in toward the earth, until, reaching a certain critical distance, it will disintegrate. Most or all of the fragments will fall to earth; perhaps a small portion may remain behind to form Saturn-like rings.

Little exception can be taken to the theory as thus far outlined. There may be some question, however, as to the state of the earth's rotation during the long interval between the times of maximum separation and final close approach. The suggestion is here offered that the earth will keep always the same hemisphere directed toward the moon during the entire interval. Darwin held that solar tidal friction will make the day longer than the month.[2]

Darwin established, as had previously been suggested by Kant, Laplace, Helmholtz, and others, that the moon is constrained in its earth-bound rotation by the gravitational attraction of the earth for the earth-produced solidified tide in the moon. Will not the idea work the other way round?

It will at once be objected that the permanent tide in the moon was formed, according to Darwin's hypothesis, as our satellite cooled from its molten state; and that the earth isn't expected to melt in the future. But is a molten state really necessary?

The rate of increase of the length of day is extremely slow, a matter of a small fraction of a second per century. On any reasonable theory there will be a period of several million years (see p. 81) during which the day and the month are sensibly equal. If there still are oceans and an atmosphere at that time,[3] as Darwin assumed, then the earth will still be subject to much the same geological processes as are operating today. The earth's crust, presumably resting upon an interior which is plastic to long-continued stresses, will still be acted upon and yielding to isostatic forces of enormously greater magnitude than the tidal forces.

[1] G. H. Darwin. *The Tides*, p. 283. Russell, Dugan, Stewart, using more recently determined values of the constants involved, give the period as 47 days.

[2] G. H. Darwin. *The Tides*, p. 294.

[3] If not, the remainder of the argument is unnecessary, as Darwin staked his case upon oceanic and atmospheric tidal friction. He recognized "earth-tides" as being highly elastic, therefore nearly frictionless.

The equilibrium form toward which all these isostatic deformations tend will then have plenty of time to embrace the "solidified" tide.

Let it be granted at once that, because of the disparity of masses, the grip of the moon upon the earth's rotation will be much less than that of the earth upon the moon's rotation. But may not even this smaller grip be sufficient to effect the postulated control? The only known example in the solar system of a satellite which revolves about its primary in a period less than the period of rotation of the latter is that of Phobos, the inner satellite of Mars. The mass of Phobos is too insignificant for this example to have any bearing on the problem in hand.

The principal question is that of the relative magnitudes of the two forces: the attraction of the moon for the "solidified" tide, and solar tidal friction. Using the inverse-sixth-power law[4] and very much the same reasoning that Darwin used in computing the relative magnitudes of the tides themselves,[5] we calculate that, under present conditions, the ratio of solar tidal friction to lunar is

$$\frac{(\text{mass of sun/mass of moon})^2}{(\text{distance of sun/distance of moon})^6} = \text{approx. } \tfrac{1}{4} \qquad (1)$$

The denominator of this fraction decreases rapidly as the distance of the moon increases. Hence it might be thought that, with a plausible increase in the lunar distance, the two effects might become sensibly equal. But here a very important new factor enters,—that of tidal lag. We have been justified in neglecting it so far, because under present conditions the solar and lunar tidal lags are practically equal. This will obviously not be the case at the future period under consideration.

Elementary geometrical considerations enable us to derive that the efficiency of tidal friction in producing rotational retardation varies as $\sin 2\alpha$, where α is the tidal lag, that is to say the angle between the axis of the tidal bulge and the radius vector to the tide-producing body. When the day becomes equal to 55 of our present days, the solar tidal lag α_s will of necessity be very small; the sun in other words will generate practically an equilibrium tide. On the other hand, the angle α_m between the axis of the "solidified" lunar tide and the earth-moon line will be free to assume any value up to $\pi/4$ which may be necessary to offset the solar tidal couple. Under such conditions it is difficult to see how the sun can wrest the earth away from the moon's gravitational control of its rotation.

The validity of the foregoing suggestion hinges largely upon three points: (1) the possibility of the formation of the solidified tide, even granting abundant time; (2) the form and magnitude of this solidified tide; and (3) the question of sufficient time under the proper conditions for its formation.

As to the first point, most geophysicists hold that the interior of the

[4] G. H. Darwin. *The Tides*, p. 281.

[5] G. H. Darwin. *The Tides*, p. 164-5.

earth is a plastic body of zero strength; that is, that any stress, however small, can produce its corresponding deformation, provided only that enough time is available. Jeffreys[6] warns us, however, that the earth's crust must also be considered in such a case, and that "the finite strength of the upper layers offers a formidable obstacle to any permanent deformation . . . where the stresses involved are not very large." It would indeed be absurd to maintain that the relatively minute tidal force could of itself produce the suggested body tide. But these considerations in no way vitiate the hypothesis advanced on p. 76, namely that the opportunity for the body of the earth to assume the form determined by the tidal force will be provided by the continued deformaitons of the earth's crust in response to forces much greater than, and quite distinct from, the tidal force. On the basis of such geophysical knowledge as we now possess, it seems almost certain that the postulated "solidified" tide must of necessity be formed, provided only that the tide-generating force act in one direction with respect to the body of the earth for a time which is commensurate with that required by major geological changes.

It might be thought that the form and magnitude of the solidified tide could be computed from the formulas for the oceanic tide according to the equilibrium tidal theory.[7] These formulas, however, are derived from a consideration of the moon's gravitational potential over the *surface* of the earth, whereas the body tide depends upon an integration throughout the *volume*.

The problem of the form assumed by a rotating plastic body in the gravitational field of another body has been treated by many mathematicians. Jeffreys[8] has summarized the results of these investigations and computed the theoretical figure of the moon under present conditions. It is an ellipsoid to a first approximation. Taking rectangular coördinates with the origin at the center of the moon, the x-axis in the earth-moon line, and the z-axis perpendicular to the plane of the moon's orbit, the three semi-axes of the ellipsoid are found to be:

$$\begin{aligned} (x) &= a\,[1 + (35Ma^3)/(12md^3)] \\ (y) &= a\,[1 - (10Ma^3)/(12md^3)] \\ (z) &= a\,[1 - (25Ma^3)/(12md^3)] \end{aligned} \qquad (2)$$

where a = mean radius of the moon, m = mass of the moon, M = mass of the earth, and d = moon's radius vector.

It would be of interest if the calculated departures from sphericity could be verified by direct observation. Dr. F. G. Pease of the Mt. Wilson Observatory has recently been engaged in making large-scale photographs of the moon for a lunar atlas. The ellipsoidal figure of the moon might conceivably give rise to a slight ellipticity in the image

[6] Harold Jeffreys. *The Earth*, p. 260.

[7] As given, for instance, by Paul Schureman in *A Manual of the Harmonic Analysis and Prediction of Tides*, (U. S. Coast and Geodetic Survey), p. 23.

[8] Harold Jeffreys. *The Earth*, p. 201.

when the moon is photographed at extreme libration, but careful measurements have failed to reveal any such effect. Any departure from a circular image due to the tidal bulge must therefore be very small as compared with topographical irregularities.

Values of the moon's departure from sphericity may be obtained indirectly, however, from the observed mean inclination of the moon's equator to the ecliptic, and the amplitude of the moon's true libration in longitude. These values come out considerably greater than those from equations (2), indicating that the moon was closer to the earth at the time of solidification than at present.[8] The theoretical values from (2), however, give us a means of comparing the magnitude of the body tide with that of a surface tide.

Because of the smallness of the departure from sphericity, it may legitimately be considered simply as the sum of two separate departures; one being tidal, the other being due to rotation. Subtracting the mean radius from each member of equations (2), we have for the departures only:

$$\begin{aligned} (x)' &= \quad (35Ma^4/12md^2) \\ (y)' &= -(10Ma^4/12md^2) \\ (z)' &= -(25Ma^4/12md^2) \end{aligned} \tag{3}$$

Now since $(x)'$ and $(y)'$ are affected equally by rotation, we may take the quantity $(x)' - (y)'$, which equals approximately $4Ma^4/md^2$, as a measure of the extreme range from "low tide" to "high tide." An interchange of constants gives us the corresponding value for the range of a body tide in the earth produced by the moon:

$$H_1 = 4\ (mA^4)/(Md^2) \tag{4}$$

where A = radius of the earth.

Let us now compare this range with that of an oceanic tide according to the equilibrium tidal theory. The height of the equilibrium tide is given approximately by

$$h = (mA^4)\ (3\cos^2\theta - 1)\ /\ (2Md^3) \tag{5}$$

where θ is the angle at the center of the earth between the moon's radius vector and the line to the point of observation.[7] The value of the parenthesis is -1 when $\cos^2\theta = 0$; 2 when $\cos^2\theta = 1$; that is, it has a range of 3 units. Therefore the extreme range of the equilibrium oceanic tide is

$$H_2 = (3mA^4)/(2Md^3) \tag{6}$$

Comparing (4) and (6), we see that the theoretical body tide is 8/3 times as great as an equilibrium surface tide. Our argument on p. 77 in regard to tidal lag will be valid if the two tides are of the same order of magnitude; thus our hypothesis does not depend upon the full theoretical magnitude of the body tide being attained.

There remains for consideration the question of sufficient time under the proper conditions for the formation of the "solidified" tide. It is essential to the validity of our hypothesis that, regardless of any effect of this slowly-forming tidal bulge, the day and the month remain sensi-

bly equal; that is, that the moon's mean position be approximately fixed with respect to a point on the earth's surface; for a time of the order of magnitude of a geological period.

The relative changes resulting from tidal friction can be computed with considerable accuracy. For instance, if one wishes to know what the distance of the moon and its period of revolution will be when our day has increased to twenty times its present length, the problem can be simply and satisfactorily solved. The total time which must elapse before this state will be attained cannot be foretold with so much confidence. There are, however, certain methods for determining roughly the time-scale involved, which is all that is necessary for our present purpose.

Observations of ancient eclipses, taken together with modern observations, make possible the computation of what is called the "secular acceleration of the moon's mean motion," given by Brown[9] as 10″.35 per century. This means that the moon occupies a position differing in longitude by 10.35 seconds of arc from the position it would now occupy had the acceleration been inoperative during the last century; or, more strictly, that the moon's mean orbital motion ω is subject to an acceleration given by the equation:

$$(d^2\omega)/dt^2) = 2 \times 10''.35 \text{ per century per century.} \qquad (7)$$

It is clear that tidal friction, by increasing the length of the day, would give rise to such an apparent "secular acceleration." If we could be sure that all the observed acceleration were due to tidal friction, equation (7) would enable us to establish the time-scale precisely; but unfortunately we have no such assurance. Brown attributes a large part, if not all, of the acceleration to a periodic change of very long period in the moon's motion, due to the slowly changing eccentricity of the earth's orbit. Moulton[10] gives 6″ as the present theoretical value of the periodic term, leaving the balance to be accounted for possibly by tidal friction, but noting that "the subject seems to be open yet to some question." There are, moreover, small changes in the earth's rotation,[11] having nothing to do with tidal friction, which nevertheless must influence secular acceleration. In view of these uncertainties, it seems hopeless to attempt to derive our time-scale from a study of lunar motions.

Probably the most dependable estimate of the time-scale is that derived from a study by G. I. Taylor and Harold Jeffreys of the friction generated by tidal currents in shallow seas. From this study it was concluded that the day has probably increased one second in length during the last 120,000 years.[12] While no great accuracy is claimed for the estimate, it is quite probably of the correct order of magnitude and will serve as a basis for our calculations of the time available for the forma-

[9] E. W. Brown. *Lunar Theory*, p. 267.
[10] F. R. Moulton. *Celestial Mechanics*, p. 350.
[11] E. W. Brown. "Observation and Gravitational Theory in the Solar System." *Pub. Astron. Soc. Pac.*, **44**, 257, 1932.
[12] Harold Jeffreys. *The Earth*, p. 228.

tion of the "solidified" tide.

Since, as shown by equation (1), the effectiveness of the sun is $\frac{1}{4}$ that of the moon in producing tidal friction, the sun must be responsible at present for $\frac{1}{5}$ of the total effect; that is, due to solar tidal friction alone, the day should increase 0.2 seconds in length during 120,000 years. Now when the day and the month become equal there can be no lunar tidal friction; this solar effect alone will remain. The value of the latter will be minute even as compared to its present value, for the earth will be rotating only about 1/50 as fast as at present. If we assume, as may be inferred from Jeffreys' discussion,[13] that tidal friction should be proportional to the cube of the rate of rotation, it follows that the increase in the length of the day during the 120,000 years should be only $0.2 \div 50^3$ or 1.6×10^{-6} seconds. To compute the cumulative effect (measured, for instance, by the moon's apparent displacement in longitude), we note that the *average* day during the 120,000 years should be longer than the day at the beginning of the interval by one-half the above amount, or 8×10^{-7} seconds. The cumulative effect during the interval should then amount to $8 \times 10^{-7} \times 365 \times 120{,}000 = 35$ seconds of time or less than 9 minutes of arc. Hence we conclude that a time of several million years must elapse during which the lunar tide-generating force will remain approximately in the same direction with respect to the solid body of the earth, a time abundantly ample, it would seem, for the formation of the "solidified" tide.

The answers thus obtained to the problems raised on p. 77 constitute quantitative evidence, conclusive as to order of magnitude even though rough approximations are made, for the validity of our hypothesis. We believe the conclusion is inescapable that, under the conditions assumed, the earth will eventually keep one face always toward the moon, because of the moon's differential gravitational attraction for permanent tidal bulges upon the earth; just as the moon is held firmly in rotational constraint by the earth at the present time.

It is freely admitted that the state of affairs visioned in the foregoing hypothesis may never actually come to pass. The very slowness of the action of tidal friction which makes the hypothesis plausible requires also that an enormously long time[14] must elapse before the day and the month become equal. There is no assurance that the assumed conditions, such as the presence of oceans and the atmosphere, will still be fulfilled; nor indeed even that the solar system will still exist in anything like its present form. It is merely maintained that under the conditions assumed, solar tidal friction can never cause the day to become longer than the month;—a conclusion which may be in itself worth while in view of the fact that Darwin's original discussion of this point appears to have been accepted without question and is to be found today in the latest text-books on astronomy.

[13] Harold Jeffreys. *The Earth*, p. 258.
[14] Jeffreys suggests 5×10^{10} years. *The Earth*, p. 230.

The Indian Calendar

By HANSRAJ GUPTA

1. The Sun and the Moon have attracted the attention of the inhabitants of the Earth even since the dawn of civilization, perhaps from even earlier times. The sacred Gayatri was written in praise of the Sun. As far back as 2000 years before Christ, we find the early Aryans offering prayers and ablutions facing the Sun. Their wisdom is now clearly brought out when we learn that the rays of the Sun mean not only light to us but so much of vital energy.

2. The Sun is the chief source of our notion of time. Any place on the equator is in light and darkness for an equal amount of time. Between one sun-rise and another there is the same period of time always on the equator. This period of time is called a day. The Hindus divide this in the following manner:

60 gharies = 1 day.
60 pals = 1 ghari.
60 vipals = 1 pal.

It will thus be seen that a vipal is $\frac{2}{5}$ of a second.

3. It is well-known that the Earth revolves round the Sun in an elliptic orbit. The time taken in one revolution is called a year. The various Hindu authorities slightly differ from each other in the matter of this period. According to the present Surya siddhanta one complete revolution takes 365 days, 15 gharies, 31 pals, 31.4 vipals, approximately, *i.e.* 365 days, 6 hours, 12 minutes, 36.56 seconds, or 365.258756481 days. According to the western authorities, it is 365 days, 5 hours, 48 minutes, 46 seconds, nearly. Thus it will be seen that the Hindus even without the help of any scientific instruments came very near to the true result, if true it may be called. The time taken by the Earth in revolving round the Sun through an angle of 30 degrees is called a month. This is not the same in all cases, because the path of the Earth is an ellipse with the Sun in one of the foci. A new month begins when the Sun enters a new sign of the Zodiac. The Hindus determined the lengths of the several months beginning with Vaisakha. Thus according to the present Surya siddhanta, the length of the month of Asadh is 31 days, 15 hours, 28 minutes, 24 seconds, while the duration of the month of Phalguna is 29 days, 19 hours, 41 minutes, 12 seconds.

4. The day according to the Hindus is considered to begin with sunrise and not from midnight. Ujjain is the Greenwich of India. The time at which the Sun enters any particular sign of the Zodiac is mentioned with reference to the sun-rise at a place on the equator with the longitude of Ujjain. The first of the month is considered to fall on the day during the course of which the Sun enters a sign of the Zodiac. This is called the time of the Samkranti. Thus the Hindu months can have days from 29 to 32. The summer months are of a longer duration

THE UNIVERSAL CALENDAR

VIKRAMA for Christian ERAS HEGIRA

BY

HANS RAJ GUPTA, M.A., GOVT. COLLEGE, HOSHIARPUR.

1		2		3		5		4	
Vaiśākha	11·233983	1	365·25875681	Sun.	0	1	354·367056	Muharram	·132944
Jyēshtha	42·169261	2	730·51751362	MON.	1	2	708·734112	Safar	29·663552
Āshādha	73·589538	3	1095·77626044	TUE.	2	3	1063·101168	Rabi I	59·194120
Śrāvaṇa	105·234261	4	1461·03502526	WED.	3	4	1417·468224	Rabi II	88·724708
Bhādrapada	136·709538	5	1826·29378407	THU.	4	5	1771·835280	Jumādaī	118·255296
Āśvina	167·178150	6	2191·55253868	FRI.	5	7	2126·202336	Jumāda II	147·785884
Kārttika	198·169538	7	2556·81129370	SAT.	6	8	2480·569392	Rajab	177·316472
Mārgāśira	228·062872	8	2922·07005851	Vikrama	Hegira	9	2834·936448	Shābān	206·847060
Pausha	257·553150	9	3287·32880533				3183·303504	Ramadān	236·377648
Māgha	286·870927							Shawwāl	265·908236
Phālguna	316·318983	6						Zeckā'dah	295·438824
Chaitra	346·139261	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Zulhijjah	324·969412
		0	31	61	92	122	153	184	214	245	275	306	337		

Key.

§1. To find the day of the week on any date of any year of the

(i) Vikrama Era.

To the date, add the quantity given in front of the month in question in table No. 1. Add also the product of 365·25875681 and the year in question. This can be readily obtained with the help of table No. 2, in which are given multiples of 365·25875681 upto 9. Divide the integral part of the sum by 7, and search out the remainder in table No. 3, which gives the required day of the week.

(ii) Al-Hegira. For tables 1 and 2, use tables No. 4 and 5 in the above process.

§2. To find the date of the Gregorian Year answering to the given date of the

(i) Vikrama Era. From the integer obtained in §1(i), subtract 22820. Divide the remainder by 146097, the remainder so obtained by 36524, the remainder now by 1461, and the remainder again by 365. If a, b, c, d, denote the successive quotients, and n the final remainder, such that n is not zero, b and d do not exceed 3, and c does not exceed 24, then the required date is the n th day from March 1, of the year (400 a + 100 b + 4 c + d) A.D.

Table No. 6 is very useful in this connection. It gives the number of days from the first of March to the first of any other month.

The reverse process is equally simple.

(ii) Al-Hegira.

To the integer obtained in §1(ii), add 226966, and proceed as in §2(i) above.

SEE EXAMPLE.

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EXAMPLE.

Consider the date:
24th Āśvina, 1353.

24	24
Aśvina	167·178150...
1000	365·258·756481...
300	328·732·830833...
50	18262·537824...
3	1287·328804...
Sum	715733·632637

Remainder: 4 [Thursday]

715733
20820

146097	694913	4 = a
36524	110525	3 = b
1461	353	0 = c
365	353	2 = d
	223	
Oct.	214	1302
	9	

694913
226966
921879

Dividing this by 354·367056, Quotient is 1920, and rem. 182·49...

This gives 6th Rajab, 1320

as compared to the winter months. It will be noticed that whereas the lengths of the Christian months are purely arbitrary, those of the Hindu months have a scientific basis. No need for leap years arises in the case of the Hindu Calendar.

5. Apart from the solar year just considered, the Hindus have a lunar year also. This corresponds to the Hijri year of the Mohammedans. The Hijri year, too, is lunar. A lunar year is of 354 days, 8 hours, 48 minutes and 33.6 seconds, nearly. Thus the lunar year is about 11 days shorter than the solar year. In three years this amounts to something more than a month. To bring the two, *i.e.* the solar and the lunar years, into closer correspondence with each other the Hindus interpolate a month in their lunar year every third year. In this manner even the Hindu lunar months give quite a good idea of the season of the year Jeth (Jyeshtha) whether of the solar or the lunar year is always hot. Pausha is always cold.

6. The chart (page 83) gives not only the day of the week on any given date of the Vikrama, Christian, and Hegira Eras, but gives also the corresponding dates of the three eras.

Planet Notes for March, 1934

By CLIFFORD E. SMITH

The *Sun* will be moving in a northeasterly direction from the central part of the constellation of Aquarius to the central part of the constellation of Pisces. On March 21 at $1^h\ 28^m$ A.M., C.S.T., the sun will cross the celestial equator from south to north. This event marks the beginning of spring. The position of the sun on the first and last days of the month will be as follows: R.A. $22^h\ 45^m$, Decl. $-7°\ 56'$, and R.A. $0^h\ 35^m$, Decl. $+3°\ 48'$.

The phenomena of the *Moon* will occur as follows:

Full Moon	March	1	at 4 A.M.	C.S.T.
Last Quarter		8	" 12 M.	"
New Moon		15	" 6 A.M.	"
First Quarter		22	" 8 P.M.	"
Full Moon		30	" 7 P.M.	"
Perigee		12	" 4 A.M.	"
Apogee		23	" 12 P.M.	"

Mercury will be in the constellation of Aquarius and, after March 5, it will be a morning object. At the beginning of the month it will be near the sun in apparent position, but by the end of the month it will rise about an hour and a half before the sun. During the early part of the month its distance from the earth will be about 60 million miles, and its apparent diameter will be about 10 seconds of arc. This distance will have increased about 20 million miles by the end of the month, and its apparent diameter will have decreased about two seconds of arc. Inferior conjunction will occur on March 5 at 6:00 P.M., C.S.T. Conjunction with the moon will occur on March 14 at $1^h\ 45^m$ P.M., C.S.T. (Mercury 42′ N). The position of Mercury on the first and last days of the month will be as follows: R.A. $23^h\ 14^m$, Decl. $-1°\ 7'$; and R.A. $22^h\ 55^m$, Decl. $-8°\ 18'$.

Venus will be a morning object in Gemini. During this period it will rise

somewhat more than two hours before the sun. At the beginning of the month its distance from the earth will be about 30 million miles and its apparent diameter will be about 48 seconds of arc. By the end of the month this distance will have increased to about 50 million miles and its apparent diameter will have decreased to about 30 seconds of arc. At noon on March 11, C.S.T., Venus will be at its greatest brilliancy for this elongation. On March 12 at $4^h\,26^m$ A.M., C.S.T., Venus will be in conjunction with the moon (Venus 6°.2 N).

Mars will be too near the sun, in apparent position, to be of interest during this period. At the first of the month it will follow about 37 minutes of time behind the sun, and this distance will decrease to about 13 minutes by the end of the month.

Jupiter will be in Virgo a few degrees north of the bright star Spica. It will be above the horizon most of the night hours since it will be at opposition early in April. Its distance from the earth during this period will be about 430 million miles, and its apparent diameter will be about 40 seconds of arc. On March 4 at $3^h\,26^m$ P.M., C.S.T., and on March 31 at $5^h\,8^m$ P.M., C.S.T., Jupiter will be in conjunction with the moon (Jupiter 6°.8 and 6°.6 N, respectively).

Saturn will be in the morning sky, but too near the sun, in apparent position, to be of interest since conjunction with the sun occurred on February 8.

Uranus will be in eastern Pisces. Thus it will be in the evening sky near the sun. At the end of the month it will set about an hour after the sun. Its distance from the earth will be about 1900 million miles, and its apparent diameter will be about 3½ seconds of arc. Conjunction with the moon will occur on March 17 at $4^h\,42^m$ P.M., C.S.T. (Uranus 5°.8 S). Its position on March 16 will be R.A. $1^h\,36^m$, Decl. +9° 23′.

Neptune will be in Leo about 2 degrees from χ Leonis. It will be above the horizon most of the night since opposition will occur on March 2 at 1:00 A.M., C.S.T. Its distance from the earth will be about 2700 million miles, and its apparent diameter will be about 2½ seconds of arc. On March 1 at $8^h\,27^m$ A.M., C.S.T., and on March 28 at $2^h\,56^m$ P.M., C.S.T., Neptune will be in conjunction with the moon (Neptune 3°.2 N). The position of Neptune on March 16 will be R.A. $10^h\,50^m$, Decl. +8° 26′.

OCCULTATION PREDICTIONS

(Taken from the *American Ephemeris*.)

Date 1934		Star	Mag.	Immersion: Greenwich C.T.	Immersion: *a*	Immersion: *b*	Immersion: Angle E from N	Emersion: Greenwich C.T.	Emersion: *a*	Emersion: *b*	Emersion: Angle E from N
				h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′.											
Mar.	1	48 Leo	5.2	2 22.2	−1.5	+0.3	111	3 38.8	−1.2	−1.4	322
	2	359 B.Leo	6.3	5 44.5	−0.2	−2.7	175	6 41.0	−2.6	−0.5	265
	18	26 Ari	6.2	23 17.2	−0.9	−1.6	99	0 20.5	−0.8	0.0	229
	24	82 Gem	6.3	21 2.0	−1.2	+1.8	82	22 19.2	−1.7	−0.6	304
	28	*d* Leo	5.1	23 47.9	−0.9	+0.1	123	1 1.4	−1.2	−0.3	306
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′.											
Mar.	1	48 Leo	5.2	2 1.8	−0.8	−0.3	133	3 14.5	−1.3	+0.3	290
	26	χ Cnc	6.2	8 47.9	+0.3	−1.7	128	9 41.0	+0.4	−1.4	283
	28	*d* Leo	5.1	23 37.1	−0.4	−0.4	139	0 39.7	−0.9	+0.9	280

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Comet Notes

By G. VAN BIESBROECK

The winter season has cut down considerably the opportunity of watching the comets that are in reach of observers at this time. No new objects have been announced since last month and only very few observations have been secured.

COMET 1933 *f* (WHIPPLE), the latest discovered object, was photographed here January 16 and 17 by Dr. Ph. Keenan as a small round coma, hardly as bright as a star of magnitude 15. It follows the predicted position (p. 49) quite closely; during the month of February it will gradually move farther into the evening sky and it will probably be difficult to extend the observations through March. Of special interest is the periodic character of this object, which describes its orbit in less than eight years. The following two independent computations show that the elements are already determined within narrow limits:

ELLIPTIC ELEMENTS OF COMET 1933 *f* (1933.0).

Computer	Whipple and Cunningham	Maxwell and Porter
Arc covered 1933	Oct. 15-Oct. 31	Oct. 15-Nov. 20
Time of perihelion	1933 Aug. 2.5858	1933 Aug. 2.4442
Perihelion to node	190° 55′ 46″	190° 53′ 21″.8
Node	188 36 16	188 32 4.0
Inclination	10 13 51	10 12 27.2
Semi-major axis	3.826692	3.82522
Eccentricity	0.346187	0.346943
Period	7.48575 years	7.48143 years

The ephemeris given last month depends on the first set of elements. Dr. Maxwell's ephemeris (*Publications of the Observatory of the University of Michigan*, Vol. 5, No. 11) differs only by +5ˢ and +1′.0 (Feb. 28) from the figures given.

No further information has become available about the faint comets 1925 II (PERIODIC SCHWASSMANN-WACHMANN) and 1932 *g* (GEDDES) during last month.

Williams Bay, Wisconsin, January 22, 1934.

Variable Stars

Monthly Report of the American Association of Variable Star Observers for December, 1933

Although the total number of observations reported herewith is the smallest for many a month, yet an examination of the records will show a satisfactory distribution over many variables, with over fifty observers contributing. In these winter months every observation secured is a valuable asset. It may be the only

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1933.

Oct. 0 = J.D. 2427346; Nov. 0 = J.D. 2427377; Dec. 0 = J.D. 2427407.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V SCL	RW AND	U PSC	S ARI	o CET	S PER
000339	004132	011712	015912	*021403*	021558
353 11.6 En	411 13.1 So	397[12.3 Pt	416[13.8 GC	392 8.9 Ah	414 9.5 Kg
364 12.0 En	V AND	429 12.1 Sz	R ARI	393 9.1 Hf	418 9.7 So
364 12.0 Bl	004435	RZ PER	021024	393 8.8 Jo	419 9.5 Kg
S SCL	401[12.0 So	012350	359 11.8 Fd	393 9.0 Cy	419 10.0 Wd
001032	419[13.6 GC	397 9.1 Jo	363 12.4 Ma	393 9.1 Je	429 9.3 Sz
353 7.2 En	X SCL	398 9.2 B	384 12.4 Fd	393 9.1 Wd	R CET
364 6.9 En	*004435*	R PSC	397 12.3 Pt	395 8.9 Ra	*022000*
365 6.5 Bl	R PSC	012502	401 12.3 So	395 9.0 Sx	385 9.4 Jo
X AND	364 12.9 En	356 9.1 Fn	414 11.2 So	396 9.0 Ah	389 10.5 Hf
001046	365 12.5 Bl	384 9.8 Fn	W AND	397 8.8 Ah	393 10.5 Cy
RR AND	RR AND	386 10.1 Ah	021143a	397 8.8 Cy	393 10.4 Jo
419 13.8 GC	004533	391 10.0 Hf	381 9.4 Jo	397 8.5 Jo	414 11.5 Wp
T AND	397 11.8 So	397 10.2 WO	386 10.0 Ah	397 8.9 Wd	RR PER
001726	411[13.0 So	397 10.2 Pt	391 9.4 Hf	398 8.9 Ah	022150
397[13.8 Wd	RV CAS	417 11.4 Gy	393 9.4 Jo	399 9.0 Hf	385 10.8 Jo
414 12.8 So	004746a	RU AND	397 9.9 Ah	399 8.9 Mn	397 9.7 Jo
T CAS	388 9.0 Pf	013238	397 10.0 Pt	400 8.8 Sx	397 11.2 Pt
001755	397 9.5 Sf	397 13.0 Pt	401 9.8 So	400 8.7 Bd	398 11.0 B
386 11.8 Ah	397 10.0 Pt	411[13.0 So	408 10.2 Gy	402 8.5 Bd	399 10.7 Hf
387 12.3 Jo	414 9.8 Sf	Y AND	414 10.6 So	402 8.5 Cy	401 10.7 Ra
389 11.9 Pk	— CAS	013338	T PER	404 8.7 Hf	402 10.7 Wa
391 11.5 B	004746b	391 11.3 V	021258	404 8.7 Sh	402 10.8 Wp
394 11.2 Mn	388 11.5 Pf	393 11.0 Cy	363 9.3 Hr	406 8.5 Cy	414 10.6 Wp
396 12.2 Pk	397 10.8 Pt	397 11.1 Sf	369 9.3 Hr	409 8.4 Hf	415 10.7 Hf
397 12.4 Jo	W CAS	397 11.0 Pt	384 9.3 Hr	411 8.1 Bd	418 10.7 So
397 11.9 Wd	004958	401 10.5 So	385 8.5 Jo	412 8.1 Bd	R FOR
397 12.0 Pt	386 12.0 Ah	402 10.6 Cy	386 8.7 Ah	413 8.2 Bd	*022426*
401 12.0 So	395 11.2 Ra	411 9.8 So	389 8.7 Jo	419 7.8 Wd	365 12.3 Bl
R AND	397 11.8 Wd	414 10.0 Sf	392 9.0 Hf	S PER	U CET
001838	397 12.2 Pt	X CAS	393 8.9 Jo	021558	*022813*
363 13.7 Ma	401 12.1 So	014958	397 8.8 Ah	363 10.0 Hr	387 6.9 Pa
397 13.5 Wd	405 12.0 B	387 11.9 Jo	397 9.3 Hr	369 10.0 Hr	391 7.0 B
418[12.4 So	414 11.8 So	388 12.3 Bn	397 9.0 Wd	375 9.2 Cy	393 7.2 Cy
S TUC	U TUC	397 12.5 Pt	397 8.8 Pt	381 9.2 Pk	393 7.0 Jo
001862	*005457*	402 12.2 Bn	398 9.1 Ra	384 10.1 Hr	397 6.8 Jo
353[13.2 En	364[13.7 En	405 10.5 B	405 9.3 Kg	385 9.4 Jo	397 7.1 Pt
362[13.5 Sl	Z CET	418 11.6 So	405 9.0 Hf	386 9.0 Pk	400 7.1 Sx
S CET	*010102*	U PER	405 9.3 Lr	386 9.3 Ah	404 7.0 Jo
001909	397 10.5 Pt	015254	419 9.3 Kg	389 9.5 Jo	416 7.7 Ra
397[12.3 Pt	414 9.4 Hb	377 9.1 Jo	419 9.3 Wd	391 9.4 B	RR CEP
T SCL	419 9.2 Hb	384 9.8 Ry	Z CEP	392 9.2 Cy	022980
002438a	U SCL	385 9.5 Sq	021281	392 9.6 Hf	397[12.5 Pt
353 12.0 En	*010630*	385 9.5 Jo	397 12.0 Pt	393 9.6 Jo	R TRI
364 11.3 En	368[13.2 En	386 9.8 Ah	o CET	395 8.9 Pk	023133
T PHE	U AND	389 9.6 Jo	*021403*	397 9.2 Cy	377 7.5 Jo
002546	010940	391 10.1 Hf	356 9.5 Fn	397 9.4 Ah	382 8.0 Jo
364[13.0 Bn	401 9.8 So	393 10.0 Jo	360 9.4 Fn	397 9.8 Pt	384 8.1 Fd
W SCL	414 9.8 So	393 10.1 Cy	369 9.0 En	397 9.7 Wd	386 8.3 Ah
002833	UZ AND	396 10.0 Sq	378 8.9 Jo	397 10.1 Hr	389 8.2 Jo
364 13.1 En	011041	396 10.1 Ry	384 9.0 Fn	398 9.7 Ra	389 7.7 Sx
U CAS	414[13.6 So	397 10.2 Ah	385 8.7 Jo	399 9.7 Sz	391 8.7 Hf
004047a	S CAS	397 10.0 Jo	386 9.1 Ah	402 9.4 Cy	392 8.5 Ah
396 14.2 Pf	011272	397 9.8 Pt	389 9.0 Sx	405 9.5 Hf	393 9.5 Je
398 13.5 B	387 10.0 Jo	402 10.3 Cy	389 8.8 Jo	405 9.5 Kg	395 8.6 Sx
RW AND	393 10.4 Jo	418 11.3 So	389 9.0 Hf	405 9.5 Lr	396 8.5 Ah
004132	397 10.4 Jo	420 9.2 Mc	390 9.0 Je	406 9.3 Cy	397 8.7 Ah
386 13.9 Ar	397 9.9 Pt		391 8.9 Hf	414 9.5 Lr	397 9.0 Sf
396 14.1 Ar	405 10.3 B				

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1933.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
R TRI	X CET	W TAU	R ORI	S AUR	T ORI
023133	*031401*	042215	045307	052034	*053005a*
397 8.1 Pt	385 8.7 Jo	397 10.3 Al	393 9.8 Cy	417 10.3 Gy	414 10.3 Hf
398 8.7 Ah	389 8.8 Jo	397 10.2 So	404 9.5 Cy	420 9.9 Mc	414 10.5 Pt
399 8.6 Wd	389 9.0 Sx	397 10.7 Pt	404 9.5 Jo	422 10.0 Mc	415 10.5 Pt
401 9.2 Ra	391 8.8 B	402 10.5 Cy	R LEP	425 9.9 Mc	416 10.6 Pt
408 9.0 Gy	393 8.9 Jo	404 10.4 Jo	*045514*	W AUR	417 10.6 Pt
409 9.6 Hf	395 9.2 Sx	418 10.4 So	362 7.0 Sl	052036	418 10.5 Pt
414 9.3 Sf	395 9.0 Ra	S TAU	381 7.6 Jo	397[12.3 Pt	AN ORI
417 9.7 Gy	397 8.8 Pt	042309	387 7.7 Jo	402[13.2 Hf	*053005t*
T ARI	397 8.9 Jo	397[13.0 Pt	387 8.5 Ra	419[13.2 GC	352 10.9 Ma
024217	408 9.7 Gy	403[12.8 Ar	389 9.4 Hf	S ORI	389 11.8 Hf
382 10.4 Jo	415 9.5 Sx	412[13.4 B	391 7.7 Jo	*052401*	393 11.6 Hf
385 10.0 Jo	417 9.8 Gy	T CAM	397 8.0 Jo	387 8.5 Jo	393 11.5 Wd
389 9.9 Jo	418 10.3 WO	043065	397 9.4 Hf	389 8.6 Jo	395 11.6 Ra
393 10.0 Jo	Y PER	377 8.6 Jo	397 7.8 Pt	391 8.4 Jo	397 11.7 Wd
397 9.7 Jo	032043	385 8.4 Jo	414 9.4 Hf	397 8.4 Jo	402 11.7 Hf
400 10.4 Bd	377 9.0 Jo	391 9.0 Hf	414 9.6 Sh	397 8.3 Pt	402 10.9 Ma
401 10.4 Ko	382 9.5 Jo	397 8.7 Jo	414 9.5 Wd	401 8.9 Ra	402 11.7 Wd
402 9.8 Bd	385 9.4 Jo	397 8.6 Pt	V ORI	404 8.8 Jo	407 11.5 Wd
408 9.6 WO	385 9.3 Sq	399 9.0 Wd	050003	421 9.7 Sr	419 11.7 Wd
411 10.4 Bd	389 9.5 Jo	404 9.2 Wd	397 11.9 Pt	T ORI	S CAM
412 10.4 Bd	390 9.4 Pk	404 9.5 Sh	401 11.3 Ra	*053005a*	053068
413 10.3 Bd	391 9.6 Hf	404 9.4 Hf	T LEP	352 10.2 Ma	381 8.5 Jo
W PER	392 9.5 Ah	404 9.1 Jo	*050022*	367 10.4 Hr	385 8.7 Jo
024356	393 9.8 Jo	RX TAU	365 11.7 Bl	375 9.6 Cy	397 8.8 Jo
377 8.5 Jo	395 9.5 Pk	043208	381 9.9 Jo	387 9.8 Jo	397 9.0 Pt
382 8.6 Jo	396 9.6 Sq	397[12.8 Pt	387 9.6 Jo	389 9.9 Jo	399 9.6 Hf
384 8.6 Fd	397 8.8 Pt	412 13.3 B	391 9.6 Jo	389 9.9 Hf	404 8.8 Jo
384 9.0 Ry	397 9.6 Ah	R RET	397 9.5 Jo	391 9.8 Jo	405 9.7 Hf
385 8.7 Jo	401 9.5 Ra	*043263*	397 10.6 Al	391 10.4 Hr	RR TAU
389 8.6 Jo	405 10.0 Hf	364 12.5 En	414 11.5 Wd	392 9.4 Cy	053326
391 9.0 B	420 10.0 Mc	X CAM	S PIC	393 9.7 Cy	392 11.7 Pt
391 9.1 Hf	R PER	043274	*050848*	393 9.8 Hf	393 11.8 Pt
392 9.2 Cy	032335	378 9.0 Jo	365 11.9 Bl	393 9.7 Wd	396 11.9 Pt
393 8.9 Jo	384[13.5 Fd	385 8.7 Jo	R AUR	393 9.9 Pt	397 11.9 Pt
393 9.2 Ry	398 12.4 B	391 8.3 Hf	050953	395 10.0 Ra	397 12.7 Cy
397 8.5 Pt	Nov PER	393 8.5 Jo	386 14.1 Ar	396 9.7 Pt	416 13.7 Wa
398 8.9 Ra	032443	393 8.6 Cy	388 14.1 Ar	397 9.7 Pt	416 13.7 Wp
399 9.2 Sx	397 13.4 Pt	397 8.2 Jo	396 13.6 Ar	397 9.6 Hf	418 12.0 WO
402 9.1 Cy	X PER	397 7.5 Pt	397 13.5 Ar	397 9.8 Cy	RU AUR
405 9.1 Hf	034930	404 8.6 Cy	397 12.6 Wd	397 10.0 Jo	053337
415 9.3 Sx	363 6.4 Hr	405 8.2 Hf	397 12.3 Pt	397 10.2 So	397[12.0 Pt
418 9.5 So	372 6.4 Hr	R DOR	403 13.3 Ar	397 9.6 Wd	420 13.8 GC
420 9.3 Mc	T TAU	*043562*	404 13.2 Ar	401 10.0 Ko	U AUR
R HOR	041619	362 5.3 Sl	407 13.2 Ar	401 9.9 So	053531
025050	367 10.7 Hr	364 5.5 En	T COL	402 9.9 Cy	397 12.6 Pt
362 8.1 Sl	391 10.5 Hr	365 5.6 Bl	*051533*	402 9.6 Hf	SU TAU
364 9.2 En	R TAU	367 5.2 Sl	365 12.0 Bl	402 9.6 Ma	054319
365 8.6 Bl	042209	368 5.7 En	S AUR	402 9.6 Wd	352 9.3 Ma
367 8.5 Sl	399 13.8 Wd	R CAE	052034	403 9.5 Ar	361 9.7 Ma
368 9.2 En	412 13.4 B	*043738*	359 11.6 Fd	404 10.2 Jo	365 10.1 Wp
T HOR	W TAU	365 9.9 Bl	389 9.3 Jo	404 9.9 Cy	375 10.2 Cy
025751	042215	R PIC	393 9.4 Jo	404 9.5 Ar	392 10.1 Cy
362 9.5 Sl	359 10.9 Fd	*044349*	395 10.8 Ra	406 9.9 Cy	392 9.7 Pt
364 9.7 En	375 10.5 Cy	365 7.7 Bl	397 10.1 Pt	407 10.0 Ar	393 9.9 Pt
365 9.5 Bl	385 10.8 Jo	V TAU	397 9.4 Jo	407 9.9 Gw	393 10.0 Cy
367 9.4 Sl	389 10.6 Jo	044617	402 10.4 Hf	407 10.3 Wd	396 9.6 Pt
368 9.0 En	392 10.4 Cy	412 12.5 B	402 10.3 Wd	414 10.2 Wd	397 9.6 Pt
	393 10.6 Jo	417 12.2 Gy	404 9.5 Jo	414 10.3 Sh	397 9.8 Cy

Variable Star Observations Received During December, 1933.

J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
SU Tau			**Z Aur**			**X Mon**			**TW Gem**			**U Pup**			**V UMa**		
054319			055353			*065208*			070122c			075612			090151		
401	9.9	Ko	393	9.7	Jo	397	8.9	Hf	393	8.5	Wd	419	12.0	GC	397	10.6	Jo
402	9.8	Cy	397	9.6	Jo	397	8.6	Jo	393	8.5	Hf	**R Cnc**			416	10.5	GC
402	9.5	Ma	397	9.8	Cy	**R Lyn**			396	7.8	Pt	081112			418	10.4	GC
404	9.4	Jo	397	9.9	Pt	065355			397	8.4	Wd	392	10.9	Cy	419	10.4	GC
414	9.6	Pt	402	10.0	Cy	386	7.8	Ah	402	8.4	Wd	396	10.8	Pt	420	11.1	GC
415	9.6	Pt	404	10.3	Cy	392	8.1	Ah	402	8.4	Hf	397	10.8	Jo	420	10.3	Mc
416	9.6	Pt	404	9.6	Jo	397	8.3	Ah	404	8.4	Hf	401	11.0	Ra	**W Cnc**		
417	9.5	Pt	411	10.6	Pt	397	8.0	Jo	404	8.4	Wd	404	10.9	Cy	090425		
417	9.3	Gv	412	10.2	B	398	8.2	Ah	**R CMi**			**V Cnc**			396	9.6	Pt
418	9.5	Pt	416	10.7	GC	399	8.8	Mn	070310			081617			397	9.9	Hf
U Ori			418	10.7	GC	404	8.0	Io	381	10.6	Jo	392	9.0	Cy	397	9.4	Jo
054920a			422	10.4	Mc	405	8.3	Hf	387	10.4	Jo	392	9.1	Ah	404	9.9	Cy
384	8.7	Je	425	10.3	Mc	**RS Gem**			396	10.0	Pt	396	9.1	Ah	**R Car**		
386	8.3	Ah	**R Oct**			065530			397	10.1	Jo	396	8.8	Pt	*092062*		
389	8.2	Hf	*055686*			396	11.4	Pt	397	10.5	Hf	397	8.8	Jo	360	9.0	Bl
390	8.3	Je	355	9.9	En	397	10.4	Jo	401	10.3	Ra	398	9.1	Ah	**X Hya**		
391	7.7	Fd	364	9.1	En	404	10.6	Jo	**RR Mon**			404	8.8	Cy	*093014*		
392	7.6	Ah	365	9.3	Bl	**V CMi**			071201			**RT Hya**			419	12.8	GC
393	7.2	Jo	**X Aur**			070109			417	13.4	GC	*082405*			**R LMi**		
393	7.6	Hf	060450			381	8.6	Jo	**V Gem**			387	7.8	Jo	093934		
393	8.0	Je	385	9.4	Jo	387	8.7	Jo	071713			391	8.4	Jo	396	11.5	Pt
393	7.6	Wd	389	9.4	Jo	396	9.8	Pt	416	14.3	GC	396	8.0	Pt	**RR Hya**		
395	7.6	Ah	393	8.5	Jo	397	9.5	Hf	**S CMi**			401	8.4	Ko	*094023*		
396	7.4	Ah	395	8.6	Ra	397	9.5	Jo	072708			**R Cha**			419	13.8	GC
397	7.3	Ah	397	8.5	Pt	401	9.4	Ra	396	11.4	Pt	*082476*			**R Leo**		
397	7.0	Jo	397	8.5	Jo	**R Gem**			401	11.5	Ra	365	10.8	Bl	094211		
397	7.5	Kg	399	9.1	Hf	070122a			**T CMi**			367	10.9	Sl	387	5.7	Jo
397	6.9	Se	399	8.7	Sx	387	9.0	Ra	072811			**U Cnc**			391	6.0	Jo
397	7.0	Wd	404	8.7	Jo	389	9.6	Jo	396	11.8	Pt	083019			392	5.8	Ah
397	7.3	Pt	**U Lyn**			389	9.4	Hf	**X Pup**			420	13.8	GC	396	6.0	Ah
398	7.1	Ah	063159			392	8.9	Ah	*072820a*			**X UMa**			396	5.8	Pt
400	6.9	Se	414	13.1	GC	393	9.3	Hf	417	8.6	GC	083350			397	6.1	Ah
400	7.2	Sx	416	13.2	GC	393	9.2	Wd	**Z Pup**			396	12.5	Pt	397	5.9	Jo
404	6.6	Jo	418	13.3	GC	395	8.8	Ah	*072820b*			**S Hya**			397	6.5	Hf
404	7.2	Hf	419	13.3	GC	396	8.0	Ah	417	11.9	GC	084803			397	6.1	Se
404	7.4	Sh	**S Lyn**			396	7.7	Pt	**S Vol**			396	11.3	Pt	398	6.1	Ah
404	7.3	Wd	063558			397	8.3	Wd	*073173*			419	12.3	GC	402	6.5	Ma
407	7.6	Kg	396	12.8	Ry	397	8.0	Jo	365	11.4	Bl	**T Hya**			404	6.5	Se
414	7.3	Kg	414	11.6	GC	397	8.1	Ah	**U CMi**			*085008*			412	6.6	Ra
414	7.5	Lr	416	11.8	GC	398	7.8	Ah	073508			392	12.3	Cy	419	6.6	Wd
417	6.8	Gv	418	11.3	GC	402	7.6	Hf	375	9.7	Cy	396	12.0	Pt	**V Leo**		
419	7.3	Kg	419	11.3	GC	402	7.5	Wd	387	9.4	Jo	404	12.1	Cy	095421		
419	6.7	Wd	**X Gem**			404	7.3	Wd	392	9.6	Cy	419	11.0	GC	387	9.0	Jo
420	6.2	Mc	064030			404	7.3	Sh	396	9.2	Pt	**T Cnc**			391	9.3	Jo
421	7.8	Sr	389	8.4	Hf	404	7.3	Hf	397	9.6	Cy	085120			396	9.8	Pt
422	6.4	Mc	397	8.6	Cy	419	6.9	Wd	397	9.4	Jo	382	8.8	Jo	397	10.4	Cy
425	6.5	Mc	397	8.4	Jo	**Z Gem**			402	9.6	Cy	387	8.7	Jo	397	9.5	Jo
V Cam			404	8.0	Jo	070122b			404	9.0	Cy	396	9.0	Pt	404	10.3	Cy
054974			404	8.5	Cy	389	12.7	Hf	406	9.2	Cy	397	8.8	Jo	419	10.7	GC
397	12.8	Pt	419	8.1	Wd	393	12.5	Hf	**S Gem**			397	9.9	Cy	**S Car**		
Z Aur			**Y Mon**			393	12.5	Wd	073723			404	9.8	Cy	*100661*		
055353			065111			396	12.8	Pt	396	13.5	Pt	**S Pyx**			360	8.8	Bl
375	10.1	Cy	397	12.8	Pt	402	12.5	Wd	**T Gem**			*090024*			**U UMa**		
381	10.2	Jo	**X Mon**			402	12.4	Hf	074323			401	11.5	Ko	100860		
385	10.0	Jo	*065208*			419	12.4	Wd	396	9.3	Pt	419	13.7	GC	367	6.5	Hr
389	9.5	Jo	387	8.5	Jo	**TW Gem**			397	9.0	Jo	**V UMa**			369	6.5	Hr
392	9.7	B	391	8.5	Jo	070122c			397	9.2	Cy	090151			391	6.5	Hr
392	9.9	Pt	395	9.0	Ra	387	8.6	Ra	404	9.0	Cy	387	9.8	Jo			

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1933.

J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
R UMA			T UMA			R CVN			S APS			R CRB			SX HER		
103769			123160			134440			*145971*			154428			160325		
387	11.6	Jo	407	8.2	Wd	397	8.1	Ah	362	10.2	Bl	389	6.0	Rb	393	8.5	Jo
389	11.7	Hf	419	8.0	Wd	397	7.7	Jo	364	10.5	En	392	6.1	Hf	397	8.5	Jo
391	11.7	Jo	RS UMA			398	8.1	Ah	S CRB			392	6.0	Ah	397	8.4	Pt
392	11.3	Cy	123459			T APS			151731			393	6.0	Jo	RU HER		
395	11.2	Ra	377	10.6	Jo	*134677*			378	7.4	Jo	393	5.9	Ko	160625		
396	11.0	Ah	384	11.5	Rc	355[	12.3	En	381	7.5	To	393	5.9	Pt	385	10.5	Jo
396	11.1	Pt	385	11.0	Jo	362[	13.2	Bl	385	7.4	Jo	396	5.9	Hr	389	10.4	Jo
397	11.4	Wd	386	11.4	Ah	R CEN			387	7.7	Ra	397	6.0	Jo	393	10.4	Jo
397	11.3	Jo	388	11.3	Bn	*140959*			389	7.5	Jo	397	6.0	Cy	393	9.8	Pt
399	10.9	Wd	389	11.8	Jo	350	6.1	Sl	392	8.0	Ah	397	6.0	Ah	397	9.6	Jo
404	10.8	Jo	392	11.5	Cy	360	7.0	En	393	7.5	Jo	397	5.9	Hr	R SCO		
404	10.6	Cy	395	12.0	Ra	360	7.0	Bl	393	7.8	Pt	397	6.0	Se	*161122a*		
407	10.8	Wd	396	12.1	Rc	361	6.5	Sl	397	8.0	Ah	397	6.0	Pt	355[	12.4	En
419	9.0	Wd	402	12.2	Bn	U UMI			398	8.0	Ah	398	6.0	Ah	S SCO		
429	8.0	Sz	404	12.4	Cy	141567			RS LIB			401	6.0	Ko	*161122b*		
V HYA			S UMA			381	9.7	Jo	*151822*			402	6.0	Cy	355[	12.4	En
104620			123961			386	9.8	Ah	355	8.1	En	404	6.0	Cy	W CRB		
387	8.0	Jo	377	10.8	Jo	389	9.7	Jo	360	8.1	Bl	404	6.0	Rb	161138		
391	8.0	Jo	385	10.7	Jo	392	9.7	Ah	R NOR			404	6.2	Se	393[	12.5	Pt
397	8.1	Jo	386	10.8	Ah	393	9.5	Jo	152849			412	5.9	Ra	U HER		
401	8.0	Ko	389	10.6	Jo	393	9.9	Cy	360	7.0	Bl	R SER			162119		
RS HYA			392	10.4	Ah	393	9.6	Pt	360	7.2	En	154615			393	13.3	Pt
104628			393	10.6	Jo	396	9.6	Ah	368	7.1	En	393	6.4	Pt	SS HER		
419	10.3	GC	395	9.8	Ra	397	9.7	Ah	W LIB			V CRB			162807		
W LEO			396	10.0	Ah	398	9.7	Ah	*153215*			154639			385	9.9	Jo
104814			397	10.1	Ah	404	9.5	Cy	360	10.0	Bl	378	7.4	Jo	389	10.0	Jo
420	11.6	GC	397	10.0	Hf	404	9.3	Jo	S UMI			385	7.6	Jo	W HER		
S LEO			398	10.1	Ah	S BOO			153378			386	7.9	Ah	163137		
110506			407	9.0	Wd	141954			387	12.5	Ra	389	7.6	Jo	378	8.5	Jo
420	11.1	GC	419	8.6	Wd	381	8.4	Jo	389	11.9	Jo	393	7.7	Jo	381	8.5	Jo
RS CEN			420	8.5	Mc	385	8.8	Jo	393	11.7	Jo	393	7.0	Pt	385	8.4	Jo
111661			429	8.1	Sz	389	8.8	Jo	393	12.2	Pt	397	7.7	Jo	389	8.5	Jo
360	9.1	Bl	U OCT			393	9.0	Jo	U LIB			398	7.8	Ah	389	8.5	Ko
T CVN			*131283*			393	9.0	Pt	*153620a*			R LUP			392	8.4	Jo
122532			355	9.2	En	397	9.4	Jo	360	10.7	Bl	*154736*			393	8.9	Pt
381	10.0	Jo	360	9.1	Bl	V BOO			T NOR			350	11.2	Sl	397	8.4	Jo
387	10.2	Jo	364	9.4	En	142539a			*153654*			362	10.8	Sl	401	8.5	Ko
391	10.7	Jo	RV CEN			386	9.1	Ah	360	7.9	En	366	10.4	Sl	R UMI		
397	9.9	Cy	*133155*			391	9.4	Jo	368	7.9	En	Z CRB			163172		
404	10.7	Cy	355	9.6	En	393	9.0	Pt	R CRB			155229			381	9.8	Jo
421	9.8	Rc	360	9.5	Bl	397	9.4	Ah	154428			384	14.4	Bk	385	9.8	Jo
U CEN			T UMI			397	9.3	Cy	359	5.8	Hr	RZ SCO			386	9.8	Sq
122854			133273			397	9.5	Jo	362	5.9	Hr	*155823*			387	10.0	Ra
360	9.4	Bl	385	9.6	Jo	398	9.4	Ah	366	5.8	Hr	355	9.1	En	389	9.8	Jo
T UMA			389	9.3	Jo	404	9.5	Cy	369	5.9	Hr	360	9.3	En	389	10.1	Hf
123160			393	9.2	Jo	U BOO			376	6.0	Cy	Z SCO			392	10.0	Sq
377	8.4	Jo	393	9.1	Cy	144918			377	6.0	Jo	*160021*			397	9.8	Jo
385	8.0	Jo	404	9.6	Cy	404	12.0	Cy	378	6.0	Jo	360	10.8	Bl	404	9.7	Jo
386	8.5	Ah	T CEN			Y LUP			381	6.0	Jo	360	10.5	En	409	10.0	Hf
389	7.9	Jo	*133633*			*145254*			382	6.0	Jo	X SCO			416	9.5	GC
392	8.5	Ah	360	7.2	Bl	362[	13.7	Bl	384	5.9	Hr	*160221a*			419	9.2	GC
393	7.8	Jo	R CVN			S APS			385	6.1	Se	360	12.6	Bl	R DRA		
395	7.9	Ah	134440			*145971*			385	6.0	Jo	SX HER			163266		
395	8.2	Ra	386	8.2	Ah	350	10.1	Sl	385	6.0	Rb	160325			381	11.2	Jo
396	7.9	Ah	387	7.8	Jo	354	10.4	En	386	6.1	Ah	385	8.3	Jo	385	11.2	Jo
397	8.1	Ah	391	7.8	Jo	360	10.5	En	387	6.2	Ra	389	8.4	Jo	386	11.0	Ah
397	7.9	Hf	392	8.2	Ah	360	10.2	Bl	389	5.8	Jo	389	8.7	Ko	387	11.3	Ra
398	8.0	Ah				361	10.2	Sl	389	6.0	Ko	393	8.3	Pt	389	10.7	Hf

Variable Star Observations Received During December, 1933.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
R Dra	RS Her	RY Her	W Lyr	R Sct	R Sct
163266	171723	175519	181136	*184205*	*184205*
389 11.5 Jo	378 7.5 Jo	392[13.4 Pt	392 8.9 Ah	350 6.0 Sl	402 5.8 Kg
393 11.1 Hf	385 7.9 Jo	V Dra	393 9.0 Cy	359 5.5 Hr	403 5.8 Ar
393 11.0 Wd	389 8.0 Jo	175654	393 9.2 Jo	362 5.5 Sl	404 5.7 Hf
393 11.7 Pt	392 8.4 Ah	393 12.2 Pt	393 9.1 Hf	363 5.6 Ae	407 5.8 Rc
397 11.3 Wd	393 8.0 Pt	R Pav	393 8.9 Je	366 5.4 Hr	409 5.7 Hf
397 11.5 Jo	397 8.8 Ah	*180363*	393 9.1 Wd	367 5.3 Sl	410 6.0 Sx
RR Oph	397 8.4 Jo	354 10.5 En	393 8.9 Pt	367 5.0 Cy	411 5.9 Pt
164319	398 8.8 Ah	360 10.6 En	395 9.4 Pk	369 5.2 Hr	411 5.9 Cy
355 9.8 En	401 8.1 So	366 11.2 En	397 9.4 Jo	372 5.4 Hr	414 5.9 Pt
360 9.4 En	402 8.9 Cy	T Her	397 9.2 Ah	376 4.9 Cy	415 6.3 Hf
S Her	S Oct	180531	397 9.5 Sf	377 5.2 Jo	415 6.0 Rc
164715	*172486*	381 11.0 Jo	397 9.4 Wd	378 5.4 Jo	417 6.0 Kg
381 9.2 Pk	355 12.2 En	386 11.0 Ah	398 9.4 Ah	378 5.0 Ko	419 6.2 Rc
382 9.4 Jo	360 12.5 Bl	388 11.1 B	401 9.9 So	378 5.6 Bc	RW Lyr
385 8.9 Jo	362 12.3 Sl	389 12.0 Jo	402 9.8 Hf	380 5.5 Bc	184243
389 8.8 Jo	364 12.4 En	389 11.2 Hf	402 9.8 Wd	380 5.2 Hr	386 12.8 B
393 8.8 Jo	RU Oph	393 11.4 Pt	404 10.3 Cy	381 5.5 Jo	386 13.0 Bk
393 9.0 Pt	172809	402 11.6 Hf	411 10.9 So	382 5.6 Jo	Nov Aql
396 8.5 Pk	392[12.6 Pt	402 11.6 Wd	413 10.7 B	384 5.5 Hr	184300
397 8.7 Jo	RU Sco	402 12.3 Cy	414 10.6 Sf	385 5.4 Jo	385 10.8 Jo
RS Sco	*173543*	417 11.6 Gy	RV Sgr	385 5.3 Kp	386 11.3 Ar
164844	354 9.3 En	W Dra	*182133*	385 5.1 Ko	389 11.0 Jo
354 11.3 En	360 9.1 En	180565	354 11.5 En	385 5.4 Se	391 11.1 Ar
360 11.4 En	360 8.9 Bl	384 11.3 Bk	360 11.1 En	386 5.4 Ar	392 11.4 Ar
360 11.2 Bl	366 8.9 En	386 11.2 Bk	361 10.6 Bl	387 5.4 Pa	392 11.5 Pt
366 11.2 En	SV Sco	387 11.4 Pf	366 10.8 En	387 5.8 Ra	396 11.3 Ar
368 11.0 En	*174135*	393 11.2 Pt	SV Her	389 5.8 Sx	397 11.3 Ar
RR Sco	362[13.0 Bl	396 10.5 Pf	182224	389 5.6 Jo	397 10.9 Jo
165030a	366[12.2 En	402 10.0 Wa	386 15.0 Bk	389 5.4 Kp	403 11.4 Ar
350 8.3 Sl	W Pav	402 10.0 Wp	T Ser	389 5.1 Ko	404 11.0 Jo
355 10.2 En	*174162*	408 9.9 GC	182306	389 5.7 Hf	RX Lyr
360 10.6 En	354 9.7 En	414 9.8 Wp	384 12.3 Bk	391 5.2 Ko	185032
360 10.3 Bl	360 9.7 En	416 9.8 Wp	RZ Her	391 5.5 Ar	386 15.2 Bk
362 10.8 Sl	360 9.6 Bl	416 9.6 Wa	183225	392 5.6 Jo	393[13.0 Pt
367 11.0 Sl	366 9.6 En	416 9.6 GC	389 10.4 Jo	392 5.3 Cy	403[13.0 Ar
RV Her	U Ara	418 9.6 GC	397 9.9 Jo	392 5.6 Ar	S CrA
165631	*174551*	419 9.8 GC	X Oph	392 5.7 Hf	*185137a*
384 15.3 Bk	354[13.0 En	X Dra	183308	392 5.4 Pt	351 12.1 Sl
RT Sco	366 13.0 En	180666	382 8.5 Jo	393 5.3 Pt	354 12.0 En
165636	RT Oph	386 15.3 Bk	387 8.2 Ra	393 6.0 Jo	360 11.4 En
355[13.0 En	175111	396 14.2 Pf	389 8.2 Jo	393 5.5 Ko	362 11.1 Bl
362[14.0 Bl	384 12.0 Bk	416 13.9 Wa	393 8.4 Jo	393 5.7 Hf	362 11.8 Sl
RT Her	387 12.0 B	416 13.9 Wp	393 8.3 Pt	395 5.8 Ra	366 11.6 En
170627	392 12.2 Pt	RY Oph	394 8.4 Mn	396 5.8 Kg	367 10.8 Sl
384 15.1 Bk	T Dra	181103	397 8.4 Jo	396 5.6 Ar	R CrA
396[14.3 Pf	175458a	393 13.0 Pt	398 8.2 Rc	397 5.8 Ar	*185537a*
RW Sco	414 12.2 GC	W Lyr	401 8.3 Ko	397 5.8 Jo	351 11.7 Sl
170833	416 11.8 GC	181136	402 8.3 Cy	397 5.2 Hr	354 10.7 En
360 12.5 En	418 11.7 GC	377 8.3 Jo	403 8.0 Rc	397 5.6 Se	360 11.1 En
362 12.8 Bl	419 11.8 GC	381 8.0 Pk	415 7.8 Rc	397 5.6 Wd	362 11.5 Bl
366 12.3 En	UY Dra	385 8.8 Jo	419 7.6 Rc	397 5.6 Pt	362 10.8 Sl
Z Oph	175458b	386 8.7 Ah	RY Lyr	398 6.0 Sx	366 11.1 En
171401	414 10.9 GC	387 8.6 Pk	184134	398 5.8 Rc	367 11.0 Sl
377 9.8 Jo	416 11.1 GC	387 8.9 Ra	393 10.0 Pt	399 5.8 Hf	T CrA
382 10.2 Jo	418 11.0 GC	388 9.0 B	397 10.0 Jo	401 5.8 Ko	*185537b*
397 10.5 Jo	419 11.0 GC	389 9.4 Jo	R Sct	401 5.8 Ra	351 13.2 Sl
		389 8.7 Hf	*184205*	402 5.7 Pa	362 13.3 Sl
		390 8.9 Je	346 6.0 Ma	402 5.8 Cy	362 13.0 Bl

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1933.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
T CrA	RU Lyr	U Lyr	RT Cyg	χ Cyg	RR Sgr
185537b	190941	191637	194048	194632	*194029*
366 12.8 En	386 13.9 Bk	393 11.7 Cy	359 11.2 Fd	384 7.0 Je	360 9.5 En
387 13.0 Sl	U Dra	393 12.4 Pt	375 12.1 Ma	385 7.2 Jo	363 9.5 Bl
Z Lyr	190967	395 11.8 Ra	385 11.9 Jo	385 7.5 Kp	366 9.0 En
185634	384 13.6 Fd	397 11.5 Jo	387 12.3 B	387 7.4 Kp	RU Sgr
387 9.7 B	387 13.9 Pf	404 11.0 Cy	387 11.6 Ra	387 7.6 Ra	*195142*
393 10.0 Pt	393 13.1 Pt	AF Cyg	389 12.9 Hf	389 7.0 Jo	355 12.0 En
397 10.0 Jo	396 13.9 Pf	192745	389 12.0 Jo	389 7.4 Kp	363 12.0 Bl
404 9.6 B	414 13.4 Wp	386 6.7 Ah	393 12.3 Jo	389 7.3 Hf	369 12.3 En
RT Lyr	W Aql	392 6.5 Ah	393 12.6 Hf	389 7.3 Sx	RR Aql
185737	*191007*	395 6.8 Ra	393 12.6 Wd	390 7.2 Je	*195202*
386 15.0 Bk	393 9.9 Pt	396 6.8 Ah	397 12.4 Wd	392 7.3 Kp	388[13.1 B
V Aql	T Sgr	397 7.3 Se	397 12.4 Wp	393 7.0 Jo	RS Aql
185905	*191017*	398 6.9 Ah	397 12.4 Pt	393 6.8 Cy	*195308*
360 7.8 Hr	393 12.4 Pt	400 7.0 Sx	397 12.4 Jo	393 7.2 Hf	388 9.9 B
369 7.9 Hr	R Sgr	401 7.0 Sx	402 12.3 Hf	393 7.2 Je	Nov Cyg
373 7.9 Hr	*191019*	TY Cyg	402 12.2 Wa	393 7.2 Wd	195553
397 7.9 Hr	355 11.8 En	192928	402 12.2 Wd	395 6.7 Ra	387[13.5 B
R Aql	360 11.8 En	393 13.0 Pt	402 12.2 Wp	395 7.1 Sx	390 13.8 B
190108	366 12.0 En	RT Aql	404 12.2 B	397 6.4 Jo	411[12.2 Pt
386 11.2 Ah	393 11.7 Pt	193311	414 11.8 Hf	397 7.0 Kp	RR Tel
389 10.8 Jo	394 12.3 B	388 13.4 B	414 11.6 Sh	397 7.0 B	*195656*
393 11.5 Jo	RY Sgr	393[13.1 Pt	414 11.6 Wd	397 6.7 Kg	355[12.6 En
393 10.9 Pt	*191033*	R Cyg	414 11.9 Wp	397 7.0 Lr	366[12.6 En
395 11.0 B	355[12.5 En	193449	417 11.0 Gy	397 6.4 Pt	Z Cyg
397 11.7 Jo	361[13.2 Bl	387 12.1 B	419 11.0 Wd	397 6.5 Se	195849
V Lyr	364[12.4 En	387 11.6 Ra	TU Cyg	397 7.0 Wd	385 8.8 Jo
190529a	367[12.0 Hr	389 12.3 Hf	194348	400 6.5 Sx	388 8.9 B
386 11.8 Bk	393[12.1 Pt	390 12.6 Bk	375 11.6 Ma	401 6.6 Ra	393 8.8 Jo
393 11.8 Pt	TY Sgr	390 12.0 Pk	384 11.1 Rc	401 6.2 Ko	397 8.5 Jo
RX Sgr	*191124*	393 12.1 Wd	385 10.4 Jo	402 6.2 Wd	397 8.5 Pt
190818	362 9.8 Bl	393 12.1 Hf	387 10.8 B	402 6.3 Hf	399 8.9 Hf
355 12.1 En	S Sgr	396 12.2 Pk	387 10.6 Ra	402 6.3 Je	402 8.9 Hf
360 12.1 En	*191319a*	397 11.9 Wd	389 11.0 Hf	404 6.0 Jo	402 8.8 Wd
366 11.8 En	355 11.1 En	397 11.9 Wp	389 10.5 Jo	404 5.4 Cy	404 8.7 Jo
RW Sgr	360 11.4 En	397 12.0 Pt	393 10.0 Jo	404 6.2 Hf	413 8.7 B
190819a	362 11.5 Bl	401 11.9 Wp	393 10.7 Hf	404 6.1 Wd	S Tel
355 10.4 En	366 11.6 En	402 11.5 Wp	393 10.7 Wd	404 6.0 Sh	*195855*
360 10.2 En	393[12.7 Pt	402 11.8 Wd	395 10.5 Rc	405 6.2 Ra	355 12.8 En
366 10.0 En	Z Sgr	402 11.8 Hf	397 10.3 Wd	405 6.2 Kp	360 12.6 En
393 9.0 Pt	*191321*	402 11.6 Wa	397 10.5 Pt	406 5.9 Ra	SY Aql
TY Aql	355[12.4 En	404 11.2 B	397 10.4 Jo	407 6.0 Kp	200212
190907	366[12.4 En	407 11.5 Wd	402 10.1 Hf	408 5.9 Gy	388 11.1 B
393 10.6 Pt	SW Sgr	408 11.6 Gy	402 10.1 Wd	410 5.6 Sx	397 10.6 Jo
S Lyr	*191331*	414 11.2 Hf	404 9.9 B	410 5.3 Ra	397 11.2 Pt
190925	355 10.2 En	414 11.1 Sh	414 9.9 Wd	414 5.5 Hf	413 12.0 B
386 14.0 B	360 10.5 En	414 11.0 Wd	419 9.9 Wd	414 5.5 Wd	S Cyg
386 14.7 Bk	363 10.5 Bl	414 11.1 Wp	X Aql	414 5.6 Sh	200357
X Lyr	366 10.5 En	417 10.0 Gy	194604	417 5.3 Gy	397 12.8 B
190926	TZ Cyg	419 9.9 Wd	387 13.1 B	417 5.4 Hf	397 12.7 Pt
360 9.4 Hr	191350	420 9.5 Mc	397[12.3 Pt	419 5.4 Wd	R Cap
369 9.4 Hr	393 10.6 Jo	422 9.5 Mc	χ Cyg	S Pav	*200514*
380 9.3 Hr	393 10.9 Pt	RV Aql	194632	*194659*	386 12.1 B
393 8.9 Pt	397 10.5 Jo	193509	355 7.8 Fn	355 7.4 En	S Aql
RS Lyr	U Lyr	397[12.5 Pt	362 7.5 Fn	360 7.5 En	*200715a*
190933a	191637	T Pav	371 7.5 Fn	362 6.0 Sl	389 11.7 Jo
393[12.7 Pt	384 11.7 Fd	*193972*	375 7.2 Ma	366 7.3 En	393 11.5 Jo
417[12.5 Gy	389 11.8 Jo	355[13.2 En	382 7.5 Jo	367 6.2 Sl	395 11.4 B
	393 11.7 Jo	362[13.2 Sl	384 6.9 Fn		397 10.6 Pt

Variable Star Observations Received During December, 1933.

J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
S Aql			RS Cyg			U Cyg			V Vul			T Aqr			R Vul		
200715a			200938			201647			203226			*204405*			205923a		
397	11.0	Jo	400	9.0	Sx	385	8.5	Jo	397	9.2	Pt	389	8.6	Hf	397	10.4	Pt
404	10.7	Jo	402	9.1	Cy	386	9.6	Ah	R Mic			389	8.5	Sq	405	9.4	B
RW Aql			402	8.9	Hf	387	8.3	Pk	*203429*			390	9.1	Bk	415	8.7	Hf
200715b			402	8.6	Je	387	9.5	Ra	363	8.5	Bl	392	8.3	Ah	TW Cyg		
363	8.5	Cy	402	8.9	Wd	388	8.0	Sq	Y Del			393	8.3	Hf	210129		
389	9.0	Jo	404	8.8	Jo	389	9.6	Sx	203611			393	8.2	Wd	397	[13.0	B
393	9.2	Jo	404	8.8	Sh	389	8.5	Jo	386	13.9	Bk	393	7.8	Jo	RS Aqr		
395	8.0	B	405	9.0	Lr	389	9.8	Hf	395	13.8	B	394	8.0	B	*210504*		
397	9.1	Jo	407	8.8	Kg	390	9.5	Je	S Del			395	7.6	Pk	394	10.5	B
397	9.5	Pt	407	8.8	Wd	393	8.7	B	203816			397	7.8	Jo	397	10.5	Pt
404	9.2	Jo	411	9.1	Cy	393	9.8	Hf	386	10.3	Ah	397	8.0	Ah	Z Cap		
R Tel			414	9.0	Hf	393	9.8	Je	389	10.4	Jo	397	8.0	Pt	*210516*		
200747			414	9.0	Kg	393	9.7	Wd	392	10.7	Ah	398	8.1	Ah	395	13.7	B
363	12.1	Bl	414	8.6	Lr	394	9.8	Mn	393	10.2	Cy	399	7.9	Hf	R Equ		
RU Aql			414	8.9	Sh	394	8.2	Pk	393	10.7	Jo	402	7.9	Hf	210812		
200812			414	8.9	Wd	395	9.8	Sx	397	11.4	Jo	402	7.9	Wd	375	[11.9	Ma
385	9.8	Jo	419	8.9	Wd	397	9.9	So	397	9.8	Pt	404	7.6	Jo	387	13.4	B
388	10.0	B	R Del			397	9.5	Kg	V Cyg			409	7.8	Hf	397	[12.9	Pt
389	9.9	Jo	201008			397	9.6	Lr	203847			415	7.7	Hf	408	[12.6	B
397	10.1	Jo	386	12.7	B	397	8.9	Jo	386	12.7	Bk	417	7.7	Hf	T Cep		
413	11.7	B	397	12.6	Pt	397	9.9	Ah	387	13.4	B	419	7.8	Hb	210868		
Z Aql			SX Cyg			397	9.9	Wd	389	12.9	Hf	RZ Cyg			378	8.5	Jo
200906			201130			397	8.5	Pt	397	13.0	Pt	204846			385	8.3	Jo
397	11.4	Pt	386	13.5	Bk	400	10.0	Sx	Y Aqr			363	10.5	Wp	386	8.3	Ar
R Sge			397	[13.5	B	400	9.5	Bd	*203905*			387	10.7	B	386	8.7	Ah
200916			RT Sgr			401	8.9	Ko	390	12.4	B	391	10.9	B	387	8.4	Sq
389	9.4	Jo	*201130*			401	10.0	So	397	11.6	Pt	397	10.9	Wp	388	8.2	Ar
393	9.2	Jo	363	10.2	Bl	402	9.6	Bd	T Del			397	11.3	Pt	389	8.5	Kp
397	9.2	Jo	WX Cyg			402	9.7	Hf	204016			402	11.0	Wp	391	8.2	Jo
404	9.3	Jo	201437b			402	9.8	Wd	388	9.9	B	402	11.1	Wa	391	8.1	Ar
RS Cyg			385	10.4	Jo	404	9.9	Sh	389	9.8	Jo	404	11.0	B	392	8.0	Ar
200938			387	10.9	Ra	404	9.2	Jo	393	9.8	Jo	408	10.8	B	392	8.5	Kp
355	7.7	Fn	388	10.4	B	411	9.9	Bd	393	10.1	Cy	414	11.3	Wa	392	8.5	Ah
362	7.9	Fn	389	10.4	Jo	411	10.4	So	397	9.8	Jo	414	11.2	Wp	392	8.7	Hf
371	7.8	Fn	389	11.0	Hf	413	10.1	Bd	397	11.0	Pt	416	11.1	Wp	393	8.9	B
371	8.9	Cy	393	10.6	Hf	419	9.9	Wd	404	10.7	Cy	416	11.2	Wa	393	8.7	Wd
376	8.8	Cy	393	10.7	Cy	420	9.7	Mc	414	10.5	Wa	416	11.5	GC	395	8.4	Sq
382	8.2	Jo	393	10.7	Wd	422	9.8	Mc	V Aqr			419	11.5	GC	395	8.7	Ah
384	8.2	Je	393	10.9	Jo	RU Cap			204102			S Ind			396	8.6	Ah
384	8.0	Fn	397	10.8	Jo	*202622*			394	8.5	B	*204954*			396	8.0	Ar
385	8.4	Jo	397	10.8	Wd	387	10.5	B	397	8.6	WO	363	6.6	Bl	397	7.9	Ar
387	8.8	Ra	400	10.7	Bd	Z Del			397	8.1	Pt	366	7.1	En	397	8.4	Pt
389	8.7	Sx	402	10.8	Cy	202817			W Aqr			368	7.0	En	397	8.6	Ah
389	8.9	Hf	402	10.9	Hf	384	9.9	Hi	*204104*			X Del			398	8.6	Ah
389	8.4	Jo	402	10.9	Wd	385	9.2	Jo	389	12.3	Hi	205017			399	8.3	Bd
390	8.6	Je	404	11.2	Jo	388	9.5	B	397	12.9	B	386	13.6	B	401	8.5	Bd
393	8.8	Je	407	10.7	Wd	389	9.2	Jo	U Cap			397	12.1	Pt	401	7.9	Ko
393	8.5	Jo	411	11.0	Cy	393	9.3	Jo	*204215*			413	11.5	B	402	7.9	Ar
393	9.0	Cy	411	10.8	Bd	397	9.4	Jo	394	11.7	B	RR Cap			402	8.2	Gw
393	8.8	Hf	413	10.8	Bd	397	9.5	Pt	V Del			*205627*			403	7.9	Ar
393	8.8	Wd	413	11.1	B	404	9.4	Jo	204318			366	[13.4	En	404	8.0	Jo
395	8.9	Sx	414	11.0	Hf	413	9.5	B	386	13.4	B	R Vul			404	7.9	Ar
397	8.9	Wd	414	11.0	Sh	ST Cyg			T Aqr			205923a			404	8.4	Hf
397	8.8	Lr	414	10.9	Wd	202954			*204405*			385	11.4	Jo	404	8.4	Sh
397	8.7	Kg	419	11.0	Wd	390	13.0	B	378	9.1	Jo	387	10.9	B	404	8.5	Wd
397	8.5	Pt	U Cyg			397	10.7	Jo	385	8.7	Jo	389	10.5	Jo	405	7.5	Ra
397	8.6	Jo	201647			397	12.8	Pt	386	9.0	Ah	393	10.4	Jo	406	7.8	Ar
399	8.5	Ko	381	8.4	Jo	417	11.8	Gy	389	8.2	Jo	397	10.0	Jo	407	7.8	Ar

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1933.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
T CEP	RU CYG	S GRU	V CAS	ST AND	R TUC
210868	213753	*221948*	230759	233335	*235265*
407 7.9 Lp	384 8.5 Je	364 9.5 En	376 8.5 Cy	387 9.4 Jo	364[12.9 En
410 7.6 Ra	385 7.5 Jo	369 9.5 En	386 8.3 Ah	391 9.8 B	R CAS
411 8.1 Bd	386 8.3 Ah	S LAC	391 7.9 Jo	393 9.5 Cy	235350
413 8.2 Bd	390 8.0 Je	222439	391 8.0 B	393 9.0 Al	386 9.5 Ah
414 7.7 Hb	391 7.7 Jo	393 11.9 B	392 7.9 Ah	402 9.7 Cy	386 9.4 Ar
414 8.3 Kg	393 8.3 Cy	393 11.8 Cy	392 8.0 Hf	414 9.9 Pt	387 9.4 Jo
414 8.2 Lr	393 7.5 Je	396 11.1 Ar	393 7.6 Cy	R AQR	388 9.6 Ar
415 8.4 Hf	395 8.1 Ry	404 11.2 Ar	396 8.1 Ah	*233815*	391 9.7 Ar
419 8.1 Wd	396 8.1 Ah	407 11.3 Ar	397 8.2 Ah	361 7.3 Ma	392 9.4 Ar
RR AQR	397 7.8 Pt	R IND	397 8.0 Sf	363 7.0 Sl	393 10.9 Hf
210903	398 8.1 Ah	*222867*	398 8.2 Ah	364 7.4 Bl	393 9.9 Wd
390 13.2 B	404 8.1 Cy	364 12.8 Bl	401 7.7 Ko	375 7.7 Ma	394 9.8 Mn
397 12.8 Pt	RV CYG	R LAC	404 8.1 Cy	377 7.6 Jo	396 9.6 Ar
X PEG	213937	223841	405 8.0 Hf	382 7.5 Jo	396 9.9 Ah
211614	397 6.5 Pt	397 9.8 Jo	414 8.0 Sf	387 7.9 Ko	397 9.6 Jo
375 9.5 Ma	RR PEG	399 9.9 Hf	W PEG	387 7.5 Pa	397 9.6 Ar
388 9.7 B	214024	414 9.6 GC	231425	389 8.0 Jo	398 9.6 B
397 10.0 Pt	361 9.6 Ma	416 9.8 GC	393 11.8 Cy	389 7.5 Sx	403 9.8 Ar
T CAP	376 10.1 Cy	416 9.4 Wa	397 11.8 WO	389 8.2 Sq	404 10.2 Ar
211615	392 10.9 B	416 9.3 Wp	397 11.2 Jo	391 8.5 Hf	407 9.8 Ar
363 11.9 Bl	393 10.8 Cy	419 9.5 GC	S PEG	393 8.3 Hf	419 10.8 Wd
394 10.9 B	397 11.3 WO	S AQR	231508	393 8.0 B	Z PEG
S MIC	R GRU	*225120*	386 8.1 Ah	393 8.4 Jo	235525
212030	*214247*	394 13.7 B	391 8.2 Hf	393 8.3 Wd	397 8.2 Jo
363 10.7 Bl	364 8.0 Bl	RW PEG	392 8.1 Ah	395 7.7 Ra	401 8.5 So
Y CAP	364 8.3 En	225914	393 8.1 Cy	395 7.6 Sx	408 8.2 Gy
212814	369 8.2 En	361 10.6 Ma	393 7.8 Je	395 8.3 Pk	414 8.5 So
386[14.3 B	V PEG	392 11.7 B	397 8.2 Ah	397 8.3 Jo	417 8.0 Gy
W CYG	215605	395 12.2 Ra	398 8.3 Ah	399 8.4 Hf	W CET
213244	388 13.4 B	399 11.9 Sz	405 8.7 Hf	401 8.3 Ko	*235715*
397 6.2 Se	U AQR	402 11.9 Wa	408 8.0 B	404 8.4 Jo	399 11.8 Sz
420 6.5 Mc	*215717*	414 12.9 Wa	414 8.3 Pt	405 8.5 Hf	Y CAS
422 6.4 Mc	394 12.1 B	416 13.0 Wa	415 8.7 Hf	408 8.4 B	235855
S CEP	RT PEG	416 13.0 Wp	Z AND	410 7.7 Sx	385[13.3 B
213678	215934	R PEG	232848	414 8.5 Pt	SV AND
378 10.7 Jo	361 13.4 Ma	230110	351 10.8 Ma	415 8.7 Hf	235939
385 10.7 Jo	413[13.3 B	386 9.4 Ah	352 10.3 Ma	419 8.1 Wd	361 9.2 Ma
387 11.2 Ra	RZ PEG	389 9.3 Sx	361 10.7 Ma	Z CAS	375 9.4 Ma
390 11.8 Bk	220133b	391 10.1 Hf	363 10.6 Ma	233956	391 8.9 B
391 11.0 Jo	393 11.2 Cy	395 9.5 Sx	369 11.1 Hr	393[13.1 Al	397 10.2 WO
393 11.1 B	T PEG	395 9.5 Ra	373 11.1 Hr	RR CAS	401 10.5 So
393 11.5 Cy	220412	397 9.8 Sf	384 11.1 Hr	235053	416 10.9 Wa
404 11.7 Cy	389[12.8 Hi	397 9.8 Ah	387 11.5 Pk	388 11.3 Bn	416 11.0 Wp
416 11.7 GC	417[12.8 Gy	397 9.4 Jo	393 10.6 Cy	408 11.9 B	
419 11.6 GC	T GRU	414 10.2 Kg	401 10.8 Ko	V CET	
RU CYG	*221938*	414 10.2 Lr	402 10.5 Cy	*235209*	
213753	369 10.1 En	414 10.5 Sf	406 10.7 Cy	364 10.1 Bl	
378 7.8 Jo		414 10.0 Pt	407 10.6 Ma		
384 8.1 Ry			411 10.7 Cy		

RAPIDLY VARYING IRREGULAR VARIABLES.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	Star	J.D.	Est.Obs.	J.D.	Est.Obs.
005840 RX ANDROMEDAE—					005840 RX ANDROMEDAE—				
	7384.5	11.4 Ry	7393.8	10.8 Cy		7397.7	12.7 Pt	7416.6	11.2 Wa
	7386.4	11.7 Ry	7395.4	11.6 Ry		7397.8	12.5 Cy	7416.7	11.3 Wp
	7392.7	11.5 Pt	7396.3	12.3 Ry		7414.5	13.1 So	7418.7	11.8 Pt
	7392.4	11.2 Ry	7396.8	12.6 Pt		7414.6	12.5 Wp		
	7393.7	11.5 Pt	7397.6	13.2 Wp					

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1933.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
060547 SS AURIGAE—						
	7367.1	[12.0	Hr	7406.7	[12.5	B
	7369.2	[12.5	Hr	7411.7	[11.0	Pt
	7375.9	[12.5	B	7412.6	11.2	B
	7384.5	[12.5	Ry	7413.4	11.4	B
	7385.7	[12.7	Jo	7414.5	11.6	Wa
	7386.4	[12.5	Ry	7414.6	11.7	GC
	7389.7	[12.7	Jo	7414.6	12.2	Wp
	7390.8	[13.2	Hi	7414.7	12.1	Pt
	7391.1	[12.5	Hr	7415.7	12.1	Pt
	7392.6	14.3	B	7416.6	12.6	Wa
	7393.4	[12.5	Ry	7416.6	12.7	Wp
	7395.6	[11.5	Ry	7416.6	12.6	GC
	7396.8	[12.6	Pt	7417.5	[12.5	Gy
	7397.7	[12.6	Pt	7418.7	[12.5	Pt
	7401.9	[12.5	Ko	7419.6	[13.8	GC
	7402.6	[13.9	Wa	7420.7	[13.9	GC
	7404.9	[12.5	B			
074922 U GEMINORUM—						
	7352.8	[13.8	Ma	7404.9	[13.3	Cy
	7369.2	[12.5	Hr	7406.7	[12.4	Cy
	7375.9	[12.4	Cy	7414.6	[13.3	GC
	7392.8	[12.4	Cy	7416.7	[13.8	GC
	7393.8	[12.4	Cy	7417.7	[11.7	Pt
	7397.9	[12.5	Jo	7418.6	[13.8	GC
	7401.9	[12.4	Ko	7420.7	[13.8	GC
	7402.8	[13.8	Ma			
081473 Z CAMELOPARDALIS—						
	7385.9	11.3	Cy	7402.5	11.5	Ry
	7386.4	12.5	Ry	7402.7	11.3	Cy
	7389.5	11.1	Ko	7404.6	11.5	GC
	7392.7	11.1	Pt	7404.6	11.5	GC
	7392.9	11.4	Cy	7404.9	11.8	Cy
	7393.7	11.4	Pt	7411.7	11.5	Pt
	7393.8	11.3	Cy	7414.6	11.2	GC
	7395.6	11.8	Ry	7415.7	11.6	Pt
	7396.5	11.8	Ry	7416.6	11.7	GC
	7396.8	11.7	Pt	7417.5	11.6	Gy
	7397.7	11.8	Pt	7418.5	11.9	GC
	7397.9	11.4	Cy	7419.5	12.0	GC
	7401.6	11.3	Ko	7420.9	12.1	GC
094512 X LEONIS—						
	7396.8	11.8	Pt	7419.8	11.1	GC
174406 RS OPHIUCHI—						
	7352.5	9.6	Ma	7389.5	11.0	Jo
	7363.5	9.8	Ae	7392.7	11.0	Pt
	7376.5	10.5	Cy	7393.5	11.0	Jo
	7377.5	10.0	Jo	7397.5	11.2	Jo
	7378.5	10.2	Jo	7402.5	11.7	Wa
	7381.5	10.3	Jo	7402.5	11.6	Wp
	7382.5	10.5	Jo	7404.5	11.0	Jo
	7385.5	10.8	Jo			
202946 SZ CYGNI—						
	7392.7	9.5	Pt	1414.7	9.0	Pt
	7393.7	9.7	Pt	7415.7	9.5	Pt
	7396.8	8.9	Pt	7416.7	9.5	Pt
	7397.7	8.7	Pt	7417.7	9.7	Pt
	7411.7	9.0	Pt	7418.7	9.7	Pt
213843 SS CYGNI—						
	7342.7	11.6	Ma	7393.6	12.3	Wd
	7345.8	10.2	Ma	7393.7	11.9	Pt
	7346.7	9.7	Ma	7394.6	12.0	B
	7348.6	9.9	Ae	7394.7	12.0	Pk
	7351.7	11.6	Ma	7395.6	12.0	B
	7352.5	10.8	Ma	7395.7	12.2	Pk
	7352.8	11.3	Ma	7396.5	12.0	Ah
	7353.5	11.6	Ae	7396.5	12.2	Ar
	7359.7	9.5	Fd	7396.6	12.0	B
	7359.9	10.4	Hr	7396.7	12.2	Pk
	7361.8	11.0	Ma	7396.8	11.8	Pt
	7362.7	11.5	Fd	7397.3	12.1	Ah
	7363.0	11.2	Hr	7397.5	12.1	Ar
	7365.6	11.9	Ae	7397.5	12.1	So
	7367.1	11.8	Hr	7397.5	12.3	Wp
	7369.2	11.6	Hr	7397.6	12.0	Wd
	7369.9	11.7	Hr	7397.6	12.0	Pk
	7372.6	12.0	Ae	7397.6	12.0	B
	7373.0	11.7	Hr	7397.6	11.8	Cy
	7375.7	11.9	Ma	7397.7	11.8	Pt
	7376.6	11.8	Cy	7397.8	11.9	Jo
	7377.6	11.9	Jo	7397.9	12.0	Hr
	7378.6	11.8	Jo	7398.5	12.0	Ah
	7380.9	11.8	Hr	7398.6	12.0	B
	7381.6	11.9	Jo	7399.6	12.1	Wd
	7382.6	11.8	Jo	7399.7	12.0	Pk
	7384.9	11.9	Hr	7401.5	11.9	Ko
	7385.6	11.9	Jo	7401.5	11.8	So
	7386.3	12.0	Ah	7401.6	12.3	Wp
	7386.6	12.2	Pk	7402.5	12.1	Wp
	7386.6	12.0	B	7402.5	12.0	Cy
	7386.6	12.0	Ae	7402.5	12.1	Ar
	7386.6	12.0	Ar	7402.6	12.0	B
	7387.6	12.0	B	7402.6	12.1	Wa
	7387.7	12.0	Pk	7403.5	12.1	Ar
	7387.8	12.0	Ra	7404.5	12.0	Ar
	7388.6	12.0	B	7404.5	11.8	Sr
	7388.7	12.1	Ar	7404.6	11.9	B
	7389.5	11.9	Ko	7404.6	11.9	Cy
	7389.6	11.9	Jo	7404.6	11.9	GC
	7389.6	12.0	Pk	7405.6	11.9	B
	7389.6	12.0	Hf	7405.7	12.1	Ra
	7390.6	12.0	B	7406.6	11.9	Cy
	7390.7	12.0	Pk	7406.6	12.0	Ar
	7391.1	12.0	Hr	7407.5	12.0	Ar
	7391.5	12.1	Ar	7407.5	12.0	Lp
	7391.6	12.0	B	7407.5	11.9	Wa
	7391.8	11.9	Jo	7407.6	12.3	Ma
	7391.8	11.9	Fd	7407.6	12.0	Wd
	7392.3	12.0	Ah	7408.5	12.0	B
	7392.5	12.0	Ar	7408.5	11.8	GC
	7392.6	11.8	Jo	7410.6	12.0	B
	7392.6	12.0	B	7411.5	11.9	Cy
	7392.7	12.1	Pk	7411.7	11.7	Pt
	7392.7	11.7	Pt	7412.6	11.9	B
	7393.6	11.9	Jo	7413.5	12.0	B
	7393.6	12.0	B	7414.5	11.8	GC
	7393.6	12.0	Cy	7414.5	11.5	So
	7393.6	12.3	Hf	7414.5	12.1	Wa

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1933.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	Star	J.D.	Est.Obs.	J.D.	Est.Obs.
213843 SS CYGNI—					213843 SS CYGNI—				
	7414.6	11.7 Ae	7415.6	12.0 Wa		7417.5	12.1 Wa	7418.7	11.7 Pt
	7414.6	11.9 Hf	7415.7	11.7 Pt		7417.7	11.7 Pt	7419.5	12.0 Wd
	7414.6	11.8 Sh	7416.5	11.7 Ae		7418.5	11.8 GC	7419.5	11.8 GC
	7414.6	11.9 Wd	7416.5	11.7 GC		7418.6	11.8 So	7429.6	11.5 Sz
	7414.6	12.0 Wp	7416.6	12.0 Wp		7418.6	11.8 Ae		
	7414.7	11.6 Pt	7416.7	11.7 Pt					

SUMMARY FOR DECEMBER, 1933.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Ahnert	Ah	41	129	Leuchinger	Lr	8	11
Allen, L. B.	Ae	3	10	Marsh	Ma	21	40
Allen, P. R.	Al	4	4	McLeod	Mc	11	19
Armfield	Ar	11	63	Mennella	Mn	6	6
Baldwin	Bl	60	62	Parthe	Pa	3	4
Beck	Bk	20	21	Peltier	Pt	164	224
Bordes	Bd	5	21	Perkinson	Pk	11	29
Bouton	B	89	132	Preucil	Pf	7	9
Brown	Bn	3	5	Raphael	Ra	53	62
Buckstaff,R.N.	Bc	1	2	Recinsky	Rc	3	9
Cilley	Cy	57	146	Rosebrugh	Rb	1	3
Ensor	En	59	111	de Roy	Ry	9	24
Ford	Fd	11	14	Salanave	Sx	14	32
Friton	Fn	4	13	Scanlon	So	27	42
Georgetown	GC	35	75	Schenkman	Se	7	12
Gregory	Gy	18	24	Shinkfield	Sl	16	34
Grunwald	Gw	2	2	Shultz	Sz	7	8
Hartmann	Hf	59	137	Smith, F. P.	Sq	7	11
Hildom, A.	Hi	4	4	Smith, F. W.	Sf	10	12
Holt	Hb	3	4	Smith, L.	Sh	14	16
Hurahata	Hr	15	56	Smith, R.	Sr	3	3
Jansen	Je	9	22	Watson	Wa	15	22
Jones	Jo	113	390	Webb	Wd	42	125
King	Kg	9	19	Woodstock	WO	15	22
Kirkpatrick	Kp	3	11	Woods	Wp	17	36
Kohman	Ko	20	31				
Leopfe	Lp	2	2	Totals		52	348	2313

observation in a long time and at a critical point in the light curve, so it behooves all variable star observers to take advantage of every opportunity for observing and report observations, however few in number.

According to observations just received from Mr. Bouton at St. Petersburg, Florida, SS Cygni was on the rise to maximum on December 30. The duration of this last minimum was over seventy days, one of the longest on record.

U Camelopardalis, with an Nb spectrum and a period of 418 days, requires even closer attention than it has required in the past, partly in order to confirm the suspicions of a secondary minimum and whether or not there exists a long term period as has been found for V Hydrae, W Orionis, and similar red variables. A note to the Curator of Charts will bring a chart of the region to interested observers.

LEON CAMPBELL, Recorder.

January 11, 1934.

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

On account of the large amount of tabular material describing the data secured by coöperating groups for the Leonids, as well as a few late isolated reports, general remarks will be cut short. The table is arranged in regional groups, alphabetically by state in which the director observes. Unless the remarks state otherwise, the paths were plotted.

We are now at work on heights for the local network: after they are completed, computations will be undertaken for data from other regions. The faintness of the average meteor during this last return of the Leonids makes duplicate or multiple identification more difficult than usual. We hope that all this work will be completed during the spring.

We welcome as new members the following:

G. H. Adamson, Tecumseh, Mich.
R. L. Andrews, Greenville, Texas.
L. E. Armfield, Milwaukee, Wis.
Mrs. L. E. Armfield, Milwaukee, Wis.
J. L. Bailey, Jr., San Diego, Calif.
F. M. Bateson, Wellington, New Zealand.
J. L. Black, Cleveland, Ohio.
Mrs. J. H. Blair, East Point, Ga.
A. F. Boyd, Wauwatosa, Wis.
M. L. Braun, Salisbury, N. C.
R. Brew, Rochester, N. Y.
E. H. Bryan, Jr., Honolulu, T. H.
L. I. Buttles, Chicago, Ill.
J. Caliri, Rochester, N. Y.
F. A. Campbell, Brooklyn, N. Y.
J. Christ, Rochester, N. Y.
A. Davidson, Calgary, Alberta, Canada.
H. M. Dupree, East Point, Ga.
J. W. Graham, Salem, Oregon.
H. Harman, Ash Fork, Ariz.
B. L. Harrell, Gadsden, Ala.
N. J. Heines, Paterson, N. J.
W. L. Holt, Boston, Mass.
W. Jones, Bristol, Tenn.
G. P. Kirkpatrick, Piermont, N. Y.
A. Komori, Honolulu, T. H.
E. Loreta, Bologna, Italy.
Louisville Astronomical Society, Louisville, Ky.
T. S. Maffitt, Palestine, Texas.
Mrs. R. B. Malloy, Corsicana, Texas.
Miss S. E. Mitchell, Honolulu, T. H.
E. Mittendorf, Lorain, Ohio.
H. A. P. Myers, Seattle, Wash.
N. Nishimura, Honolulu, T. H.
P. O. Parker, Cohutta, Ga.
A. M. D. Pender, Surrey, England.
*R. Pierce, Nashua, Iowa.
F. Preucil, Joliet, Ill.
H. Raphael, San Francisco, Calif.
C. Ray, Meridian, Miss.
*S. Rupert, Exeter, Calif.
*L. Sicherman, Brooklyn, N. Y.
Miss L. Steadman, Honolulu, T. H.
A. Tonkin, Knoxville, Tenn.
C. A. Travis, Milford, Mich.
R. Vogel, Rochester, N. Y.
Y. Watanabe, Maui, T. H.
F. Weed, Jr., Jefferson City, Tenn.
C. R. West, Timpas, Colo.
J. Y. West, East Radford, Va.
B. Williams, Somerville, Mass.

*Probational member.

To save space, full addresses are not given. Members can always obtain addresses of their observing neighbors by writing in for them. We plan to issue a new membership list in the near future.

Observer and Station	1933 Nov.	Began	Ended	Total	Met.	F.	Rate	Cr.R.
(*1)E. H. Bryan, Jr., Honolulu, T. H.	14	13:25	17:00	200	42+	1.0	13	13
(*1, 2)	15	13:25	17:18	233	92	1.0	23.7	23.7
(*1)	16	13:30	16:30	180	27	0.5	9.0	18.0
(*1)	17	13:50	16:13	143	27+	0.4	11	..
(*1)	18	15:30	17:15	105	25	1.0	14.3	14.3
(*1)	19	16:00	17:15	75	22	1.0	17.6	17.6
(*3, 4, 8) Miss Larrabee's Students,	13	12:00	16:30	110	28	1.0	15.3	15.3
(*3, 5, 8) Honolulu, T. H.	14	11:15	17:20	850	278	1.0	19.6	19.6
(*3, 6, 8)	15	11:30	17:00	985	372	1.0	22.6	22.6
(*3, 7, 8)	16	13:00	17:30	710	227	0.8	19.2	24.0
(*3, 4, 8)	17	13:30	16:00	150	27	0.6	10.8	18.0

Observer and Station	1933 Nov.	Began	Ended	Total	Met.	F.	Rate	Cr.R.
(*8) Miss Larrabee's Students	19	14:25	15:30	65	11	1.0	10.0	10.0
(*8) Miss L. M. Larrabee,	14	15:15	16:15	60	12	1.0	12.0	12.0
(*8) Honolulu, T. H.	15	14:50	16:50	120	11	1.0	5.5	5.5
(*8) Miss S. E. Mitchell, Honolulu...	13	15:22	16:22	60	26	1.0	26.0	26.0
(*8) Miss L. Steadman, Honolulu ...	16	13:30	15:45	135	40	1.0	17.8	17.8
(*8) Y. Watanabe, Maui, T. H.	14	13:30	14:15	45	4	1.0	5.3	5.3
(*8)	16	12:00	14:00	120	13	1.0	6.5	6.5
COLORADO:								
Alpha Nu Fraternity, Alpha Chapter,	14	12:00	16:00	240	37	1.0	9.2	9.2
Boulder, Colo.	15	11:00	17:00	360	71	0.8	11.9	14.9
	16	12:00	16:00	240	56	1.0	14.0	14.0
(*9) Alpha Nu Fraternity, Beta	14	12:00	16:01	241	16	1.0	..	..
(*10) Chapter, Denver, Colo.	15	11:00	17:01	361	31	1.0	..	..
(*11)	16	12:00	16:01	241	25	0.9	..	..
Alpha Nu Fraternity Group, Beta Chapter, Denver, Colo.								
(*8) J. A. Bruggeman	14	12:11	15:20	180	82	1.0	27.3	27.3
(*8)	15	11:05	17:05	360	173	1.0	28.8	28.8
(*8) T. J. Bartlett	15	11:15	17:00	330	193	1.0	35.1	35.1
(*8) I. Sallen	15	12:30	14:40	120	29	1.0	15.5	15.5
(*8) M. Filmer	15	12:00	15:10	150	70	1.0	28.0	28.0
(*8) F. Spradling	15	12:00	14:20	120	44	1.0	22.0	22.0
(*8) Miss G. Kallgren	15	12:00	15:15	150	65	1.0	26.0	26.0
(*8) Miss D. Messmer	15	12:00	15:15	150	62	1.0	24.8	24.8
(*8, 12) Miss C. A. Petrie	16	12:15	16:00	205	68	1.0	19.9	19.9
(*8) C. Pydock, Louisville, Colo.	14	12:01	15:58	237	75	1.0	19.0	19.0
(*8)	15	12:04	16:03	239	61	0.9	15.3	17.0
(*8) Boulder, Colo.	16	12:17	16:01	224	58	1.0	15.5	15.5
C. R. West, Timpas, Colo.	15	13:00	16:01	180	33	1.0	11.0	11.0
FLORIDA:								
(*13) J. H. Kusner, G. Anderson, Gainesville, Fla.	17	12:00	16:00	240	40	1.0	..	..
(*14) J. H. Kusner, Gainesville, Fla...	18	14:00	15:00	60	5	0.7	5.0	7.1
R. J. Sweitzer, Gainesville, Fla.	17	13:40	16:00	140	25	..	10.7	..
B. M. Kinser, Eustis, Fla.	16	13:47	14:51	64	7	..	6.6	..
O. S. Specht, Forest City, Fla.	15	14:25	15:05	40	9	1.0	13.5	13.5
	16	15:00	16:00	60	9	1.0	9.0	9.0
S. H. Schlappich, Lake Worth, Fla...	14	12:00	13:10	70	18	1.0	15.4	15.4
	15	12:45	14:10	85	24	1.0	16.9	16.9
(*8)	16	11:45	14:45	180	6	0.1	..	..
(*15) R. Nichols, M. Iler,	16	12:34	13:17	43	5	1.0	7.0	7.0
(*15) St. Petersburg, Fla.	17	7:53	9:10	77	5	0.9	4.3	4.8
(*16) Miss Hawes, Winter Park, Fla.	16	12:00	17:45	345	21	..	..	..
MICHIGAN:								
(*17) W. J. Persons, Kalamazoo, Mich.	16	12:00	16:03	128	25	0.5	11.7	..
(*18) Miss S. Urquhart, Detroit, Mich.	15	12:40	16:00	160	12	0.7	4.5	6.4
(*8, 18) H. Armiger, Detroit, Mich...	15	12:40	16:00	200	28	0.7	8.4	12.0
(*8, 18) B. Claes, Detroit, Mich.	15	12:40	15:50	180	23	0.7	7.7	11.0
(*8, 18) M. Vann, Detroit, Mich.....	15	12:40	16:10	190	20	0.7	6.3	9.0
MISSOURI:								
(*19) J. W. Simpson, Webster Groves	13	12:00	13:45	90	27	0.9	18.0	20.0
(*19) Eureka, Mo.	14	15:00	17:00	100	40	0.9	24.0	26.7
(*19) Union, Mo.	15	13:50	14:45	55	28	1.0	30.5	30.5
(*19) Union, Mo.	16	13:20	14:50	90	37	1.0	24.7	24.7
(*19) A. M. Simpson, Webster Groves	14	14:30	16:00	90	38	0.9	25.3	28.1
(*19) Eureka, Mo.	16	12:45	15:45	180	175	0.8	58.3	72.9
(*19) J. F. Hickerson, Webster Groves	15	13:37	15:30	113	58	0.9	30.8	34.2
(*19) J. F. Moeller, Webster Groves..	13	12:00	13:45	90	18	0.9	12.0	13.3
(*19) Eureka, Mo.	14	15:15	17:00	100	15	0.9	9.0	10.0
(*19) Union, Mo.	16	13:10	15:20	120	46	1.0	23.0	23.0
(*19) R. Paubel, Webster Groves, Mo.	14	14:25	16:00	95	22	0.9	13.9	15.4

Observer and Station	1933 Nov.	Began	Ended	Total	Met.	F.	Rate	Cr.R.
(*19) R. Paubel, Eureka, Mo.	16	13:10	15:40	150	131	0.8	52.4	65.5
(*19) K. Barnet, Union, Mo.	15	14:00	15:00	60	35	1.0	35.0	35.0
(*19) E. E. Friton, Kirkwood, Mo.	15	13:00	17:30	195	40	0.9	12.3	13.7
(*19) P. M. Lindsay, Los Angeles,	13	12:02	17:18	316	41	0.7	7.8	11.1
(*19) Calif.	14	12:21	16:56	275	34	0.6	7.4	12.3
NEW JERSEY:								
(*20) R. B. Butler and associates,	14	14:20	15:18	58	5	0.9	..	..
(*20, 21) Plainfield, N. J.	15	11:00	15:35	215	21	1.0	..	..
(*22) J. Stephenson, Brooklyn, N. Y.	16	12:00	14:30	150	4	0.5	..	..
(*23) N. J. Heines, E. Patterson, N. J.	14	12:00	14:30	150	6	0.2	..	..
(*24)	15	11:00	15:30	270	30	1.0	6.7	6.7
(*25)					58	1.0	12.9	12.9
(*26)					37	1.0	8.2	8.2
(*27)					73	1.0	16.2	16.2
(*24)	16	12:00	14:30	150	26	1.0	10.4	10.4
(*25)					37	1.0	14.8	14.8
(*28)					41	1.0	16.4	16.4
(*29) G. P. Kirkpatrick,	14	13:30	15:40	130	39	1.0	18.0	18.0
(*30) Piermont, N. Y.	15	11:40	17:00	295	71	1.0	14.4	14.4
(*31)	16	12:00	16:00	240	43	1.0	10.7	10.7
H. A. Burns, Princeton, N. J.	15	12:15	13:05	50	2	1.0	2.4	2.4
(*32) F. J. Volz, Trenton, N. J.	15	11:10	13:00	110	8	1.0	4.4	4.4
(*33) G. H. Euart, J. L. Euart,	14	13:00	15:00	120	11	0.8	..	..
(*34) Providence, R. I.	16	13:30	16:00	150	26	1.0	..	..
NEW YORK:								
(*20) J. S. Allen, Hamilton, N. Y.	15	13:00	15:00	120	8	1.0	..	..
(*8) J. E. Merrill, Snyder, N. Y.	15	12:45	16:00	195	29	0.8	8.9	11.1
(*8)		12:35	16:00	205	27	0.8	7.9	9.9
(*35) Robert Brew and others, Naples, N. Y.	16	13:30	14:30	60	8	0.6	..	..
Mrs. M. Blaauw, Snyder, N. Y.	15	12:30	16:00	210	2	0.7	0.6	0.9
OHIO:								
L. La Paz, Westerville, Ohio	15	13:00	18:20	520	62	1.0	7.2	7.2
(*36) Columbus, Ohio	16	14:00	17:00	160	26	0.9	9.7	10.8
A. Brenner, Columbus, Ohio	15	13:54	15:00	66	5	1.0	4.5	4.5
	16	13:10	17:00	230	26	1.0	6.8	6.8
G. Lorenz, Columbus, Ohio	16	13:00	15:30	150	22	1.0	8.8	8.8
J. L. Black, Cleveland Ht., Ohio	16	14:30	17:30	180	6	1.0	2.0	2.0
Whitt, Menges, Schoewe, and Davis, Belfontaine, Ohio	16	12:30	16:20	230	38	1.0	..	..
Svehla, Beer, Heil, Heimbrook and Kramer, Lancaster, Ohio	16	14:00	16:00	120	10	1.0	..	..
Patterson, Rodabaugh, Blake and Southard, Sunbury, Ohio	16	13:30	17:15	225	44	1.0	..	..
Kent, Ratekin, Paddock and Thompson, Ft. Smith, Ark.	15	13:23	16:08	165	38	1.0	..	..
PENNSYLVANIA:								
S. G. Barton, Upper Darby, Pa.	15	14:24	15:30	43	5	0.7	7.0	10.0
C. P. Olivier, Philadelphia, Pa.	15	11:09	16:50	316	42	0.8	8.0	10.0
Upper Darby, Pa.	16	11:58	14:00	122	15	0.8	7.4	9.2
(*37) T. D. Cope, Philadelphia, Pa.	15	11:20	17:05	258	23	0.8	5.4	6.8
R. A. Binckley, Philadelphia, Pa.	15	12:15	17:00	285	13	0.8	2.7	3.4
F. W. Smith, Glenolden, Pa.	14	12:30	14:20	110	2	?	..	..
	15	12:30	15:00	150	18	1.0?	7.2	7.2
	16	12:30	13:45	75	6	1.0?	4.8	4.8
J. W. Evans, Brigantine, N. J.	15	11:10	15:50	240	29	1.0	7.2	7.2
R. H. Wilson, Brigantine, N. J.	15	11:10	15:50	200	33	1.0	9.9	9.9
Upper Darby, Pa.	16	14:00	16:10	130	21	0.8	9.7	12.1
(*38) Woodstock College Observa-	14	12:00	17:00	300	110	0.6	..	..
(*39) tory, Woodstock, Md.	15	11:00	17:00	360	175	1.0	..	..
(*40)		11:00	17:00	360	93	1.0	..	..

Observer and Station	1933 Nov.	Began	Ended	Total	Met.	F.	Rate	Cr.R.
(*41) Woodstock Col. Observatory	16	12:00	17:00	300	104	1.0	..	..
(*42)		12:00	17:00	300	94	1.0	..	..
(*43)		12:00	17:00	300	96	1.0	..	..
(*44) W. J. Miller, S. J.,	14	12:00	17:00	300	137	0.6	..	..
(*44) Woodstock, Md.	15	11:00	17:00	360	315	1.0	..	..
(*44)	16	12:00	17:00	300	353	1.0	..	..
J. B. Field, Sykesville, Md.	14	12:51	16:00	189	3	..	..	..
	15	11:00	17:00	360	26	1.0	4.3	4.3
	16	12:40	14:00	80	4	1.0	3.0	3.0
F. C. Oertle, Sykesville, Md.	14	12:50	15:30	160	1	..	..	..
	15	11:00	17:00	360	22	1.0	3.7	3.7
	16	12:00	14:00	120	2	1.0	1.0	1.0
(*45) P. S. Watson, Sykesville, Md...	14	12:55	15:00	125	6	..	..	..
(*34)	15	11:05	17:00	355	28	1.0	4.7	4.7
(*28)	16	12:00	14:00	120	13	1.0	6.5	6.5
(*46) E. F. Best, C. M. Jaycox,	14	12:00	16:00	240	30	0.4	..	..
(*46) Sykesville, Md.		11:00	17:00	360	195	1.0	..	..
(*46)		12:00	14:00	120	43	1.0	..	..
(*47) Naval Observatory, Washington,	14	14:00	16:00	120	6	..	3.0	..
(*48) D. C.		14:00	16:00	120	6	..	3.0	..
(*49)	15	11:00	14:00	180	19	1.0	6.3	6.3
(*50)		11:00	14:00	180	6	1.0	..	..
(*51)		14:00	17:00	180	24	1.0	8.0	8.0
(*52)		14:00	17:00	180	6	1.0	2.0	2.0
(*53)	16	12:00	16:00	240	16	1.0	4.0	4.0
(*54)		12:00	16:00	240	4	1.0	1.0	1.0
(*55) Haverford College, Haver-	15	11:30	17:00	330	101	1.0	..	..
(*55) ford, Pa.		11:32	17:01	329	97	1.0	..	..
(*55)	16	12:13	15:50	217	73	1.0	..	..
(*55)		12:10	16:00	230	56	1.0	..	..
C. B. Tomkins, West Point, Pa.	14	12:00	14:00	120	4	0.2	..	..
(*56)	15	11:00	17:00	360	36	1.0	6.0	6.0
(*57)	16	12:06	16:00	236	38	1.0	7.1	7.1
F. F. Marsh, Frederick, Md.	14	12:15	14:15	120	6	..	3.0	..
(*58)	15	12:15	16:15	240	42	1.0	10.5	10.5
(*59)	16	12:10	13:40	90	14	1.0	9.3	9.3
Miss L. B. Allen, Frederick, Md.....	14	14:15	16:15	120	10	..	5.0	..
R. D. Case, Ardmore, Pa.	15	11:55	15:00	185	28	1.0	9.1	9.1
(*60) T. K. Tomkins, North Hills, Pa.	15	11:00	15:30	270	27	1.0	6.0	6.0
(*61)	16	12:00	15:00	180	16	1.0	5.3	5.3
(*23) C. I. Williams, King George,	15	11:00	16:30	330	32	..	..	..
(*23) Va.	16	11:00	14:00	180	9	..	..	..
(*8) W. S. Mory, Waynesboro, Va.	15	13:00	15:00	120	7	..	3.5	..
(*8)	16	14:00	15:00	60	15	..	15.0	..
(*8)	17	14:00	15:00	60	6	..	6.0	..
SOUTH CAROLINA:								
(*79) W. P. Wamer, St. George, S. C.	14	12:10	16:10	240	34	0.9	8.5	9.4
(*80)	15	11:15	15:25	210	56	0.9	16.0	17.8
(*81)		11:15	12:55	100	19	0.9	11.4	12.7
(*82) E. C. Coker and students,	14	11:50	15:10	200	49	1.0	..	..
(*83) Columbia, S. C.	15	13:48	17:50	242	170	1.0	..	..
(*84)	16	13:45	18:00	255	154	1.0	..	..
(*7, 8) Mrs. F. Barrington,	14	12:00	16:00	240	12	..	..	..
(*8, 20) Charleston, S. C.	15	11:00	16:00	180	70	..	..	..
	16	12:00	16:00	240	60	..	15.0	..
O. J. Brodie, Leesville, S. C.....	15	13:45	17:15	...	4	..	..	..
TENNESSEE:								
(*62) S. Bunch, Knoxville, Tenn.....	14	12:00	15:45	209	42	1.0	12.1	12.1
(*63)	15	11:00	16:05	264	48	0.8	10.9	13.6
(*64)	16	11:48	15:17	163	30	0.7	11.0	15.7
(*65)	16	11:45	13:00	75	14	0.7	11.2	16.0
(*14) R. Rusk, Knoxville, Tenn.	14	12:00	15:00	180	14	1.0	4.7	4.7

Observer and Station	1933 Nov.	Began	Ended	Total	Met.	F.	Rate	Cr.R.
R. Rusk, Knoxville, Tenn.	15	11:06	13:00	114	3	1.0	1.6	1.6
(*28) A. Tonkin, Knoxville, Tenn.	14	12:00	15:00	180	30	1.0	10.0	10.0
(*45)	15	11:00	14:33	213	18	0.9	5.1	5.7
W. Jones, Bristol, Tenn.	15	11:00	17:00	360	46	0.9	7.7	8.6
F. Weed, Jr., Jefferson City, Tenn.	15	12:00	14:00	120	13	1.0	6.5	6.5
	16	12:30	14:00	90	14	1.0	9.3	9.3
(*67) Maryville College, Maryville,	14	13:00	16:00	180	177	1.0	..	..
(*67) Tenn.	15	13:00	16:00	180	244	0.9	..	..
(*67)	16	13:00	15:00	120	150	..	..	..
(*67)	17	15:00	16:00	60	12	..	..	..
(*68) A. Martin, Nashville, Tenn.	14	12:00	13:00	60	5	1.0	..	..
(*69) Martin Group, Nashville, Tenn.	15	12:00	17:15	230	57	1.0	..	..
L. J. Wilson, Franklin, Ky.	13	14:40	16:01	71	6	0.7	5.1	7.3
	14	12:00	15:45	158	17	1.0	6.5	6.5
	15	11:00	15:45	195	12	0.9	3.7	4.1
(*66)	16	12:00	15:50	165	24	1.0	8.7	8.7
(*70) Louisville Astronomical Society,	14	12:00	15:00	180	60	1.0	..	..
(*70) Louisville, Ky.	15	11:43	16:00	257	58	0.9	..	..
(*15)	16	15:00	16:00	60	20	1.0	20.0	20.0
(*15)	16	12:00	13:00	60	5	1.0	5.0	5.0
(*71)	14	11:45	13:30	105	15	..	8.6	..
(*71)		16:00	17:00	60	6	..	6.0	..
(*71)	16	16:30	17:00	30	7	..	14.0	..
(*71)	14	12:00	13:00	60	19	..	19.0	..
(*71)	15	13:00	14:00	60	13	0.3	13.0	..
(*71)	16	12:00	13:00	60	13	..	13.0	..
(*72)	14	12:00	14:00	120	40	..	..	..
(*72)	15	11:30	16:00	270	92	..	..	..
(*73) T. F. McConville, Ky. to Pa.	15	11:00	15:15	255	185	..	43.5	..
(*74) A. Boyles, Ensley, Ala	14	14:00	16:00	120	10	1.0	..	..
(*32, 86)	15	13:37	16:00	143	13	1.0	5.5	5.5
L. D. Hampton, Auburn, Ala.	14	15:00	16:00	60	15	1.0	15.0	15.0
	15	15:05	16:00	55	14	1.0	15.3	15.3
	16	15:00	16:00	60	9	1.0	9.0	9.0
B. L. Harrell, Gadsden, Ala.	14	12:30	15:45	195	4	1.0	1.2	1.2
(*4, 8)	15	10:55	15:00	75+	27	1.0	..	..
P. O. Parker, Cohutta, Ga.	15	11:00	16:00	300	31	1.0	6.2	6.2
UTAH:								
(*75) J. J. Hayes, Salt Lake City,	14	14:40	17:00	140	8	..	..	..
(*76) Utah	15	13:00	17:30	270	42	..	..	..
(*77) W. B. Hales, Provo, Utah.	14	12:00	16:10	250	28	1.0	6.6	6.6
(*77)	15	12:15	16:00	225	14	0.5	3.7	..
(*78)	15	12:15	15:30	195	15	0.5	..	..
WISCONSIN:								
(*85, 3) Wisconsin Group	14	12:00	16:00	855	160	1.0	11.4	11.4
(*85, 3)	15	11:00	17:00	1080	370	1.0	20.6	20.6
(*85, 3)	16	12:00	15:40	560	72	0.5	7.7	..
(*8, 20, 86) Beloit College,	14	12:00	16:00	240	5	0.9	..	..
(*8, 20) Beloit, Wis.	15	11:00	17:00	360	85	1.0	..	..
(*8, 20)	16	12:00	14:30	150	17	0.6	..	..
	16	12:00	15:00	180	5	0.4	1.7	..
(*87, 20)	14	14:00	15:00	60	3	0.8	..	..
(*87, 20)	15	11:03	16:59	356	36	1.0	..	..
(*87, 20)	16	12:00	15:00	180	5	0.4	..	..
(*87, 66)	15	11:00	15:00	240	23	1.0	5.8	5.8
(*87)	16	12:00	14:00	120	4	0.4	2.0	..
(*8, 20) Washburn Observatory,	15	11:30	16:00	270	120	1.0	..	..
(*8, 20) Madison, Wis.	16	12:00	14:20	140	15	0.8	..	..
(*61) Walter Houston, Madison, Wis.	14	11:30	13:00	90	13	1.0	8.7	8.7
	15	12:00	14:00	120	8	1.0	4.0	4.0
(*15) Milwaukee Astronomical Soci-	14	12:00	16:00	240	28	1.0	7.0	7.0
(*15) ety, Milwaukee, Wis.	15	11:00	17:00	300	43	1.0	8.6	8.6

Observer and Station	1933 Nov.	Began	Ended	Total	Met.	F.	Rate	Cr.R.
(*15) Mil. Astr. Soc. (continued)	16	12:00	16:00	240	7	0.1	1.8	..
(*15)	14	12:00	16:00	240	13	1.0	3.2	3.2
(*15)	15	12:00	17:00	180	21	1.0	7.0	7.0
(*15)	15	11:00	16:00	180	27	1.0	9.0	9.0
(*15)	16	12:00	15:40	200	9	0.5	2.7	..
(*15)	16	12:00	15:40	220	7	0.6	1.9	3.2
(*88) E. R. Reich, Marshfield, Wis...	14	12:00	14:00	120	21	0.8	10.5	13.1
(*89)	15	12:00	14:00	120	34	1.0	17.0	17.0
V. J. Niebuhr, Reedsburg, Wis.....	14	12:00	16:00	195	7	0.9	2.2	2.4
	15	11:00	17:00	360	38	1.0	6.3	6.3
	16	12:00	14:00	120	4	0.4	2.0	..
(*20, 29) The Godfrey Club,	14	12:00	14:00	120	26	..	..	..
(*20, 37) Watertown, Wis.	15	12:00	14:00	120	38	1.0	..	..
(*90) A. Klapperich, Lake Geneva,	14	12:00	16:00	240	12	..	..	..
(*90) Wis.	15	12:00	14:30	150	14	..	..	..
(*90)	16	13:00	14:15	75	16	..	..	..
F. Preucil, Joliet, Ill.	15	12:00	14:30	150	13	1.0	5.2	5.2
	16	12:00	14:00	120	12	1.0	6.0	6.0
(*8, 86) E. P. Martz, Oak Park, Ill...	14	11:00	15:00	240	5	..	1.2	..
(*60)	15	10:56	17:10	254	16	1.0	3.8	3.8
(*14)	16	13:30	15:00	90	5	0.9	3.3	3.7
V. Robinson, Crawfordsville, Ind....	17	12:00	13:00	60	1	1.0	1.0	1.0
INDEPENDENT OBSERVERS:								
J. Fraser Paterson, Broken Hill, Australia	17	13:00	15:40	160	25	1.0	9.4	9.4
(*8) B. Keller, Westtown, Pa.	15	13:00	15:00	120	45	0.9	22.5	25.0
(*91) A. M. Hannon, Carmel, Cal. ...	16	15:00	17:00	120	74	1.0	37.0	37.0
	17	15:45	17:36	111	31	1.0	16.8	16.8
S. L. O'Byrne, Ranken, Mo.	14	12:00	16:00	223	48	1.0	12.9	12.9
	15	11:00	13:00	120	22	0.9	11.0	12.2
	16	12:00	16:00	240	26	1.0	6.5	6.5
(*8) J. M. Magner, Ranken, Mo.	14	12:00	16:00	240	91	1.0	22.8	22.8
(*8)	15	11:00	13:00	120	29	0.8	14.5	18.1
(*8)	16	12:00	13:00	60	61	1.0	61.0	61.0

REMARKS.

(1) Not plotted, but detailed notes on each. (2) Dawn at end. Maximum between 15:00 and 16:00. (3) This is the total observing time for the whole party. The rate given is the average individual rate. (4) Two observers. (5) Thirteen observers. (6) Eleven observers. Maximum rate for epoch between 15:00 and 16:00. (7) Six observers. (8) Count. (9) Two plotters, duplicate paths for most meteors. (10) Three plotters; 2nd began at 12:30, 3rd at 3:15. Duplicate paths for many meteors, triplicate for some. (11) Four plotters; duplicate paths for many meteors, triplicate and quadruplicate for some. (12) Only 18 of these were Leonids. (13) 14 plotted. (14) 3 plotted. (15) Only one observer at a time. (16) These plotted; about 40 per hour seen from 12:00 to 16:00; about 80 to 100 per hour seen from 16:00 to 18:00. (17) 19 plotted; two assistants. (18) Observing period reported in January Meteor Notes. (19) Probably partly or entirely count. (20) Group of observers. (21) 19 plotted. (22) Four assistants. (23) "We" counted. (24) Count by Mr. Montmeant. (25) Count by Mr. Goldstien. (26) Count by Mr. Oksner. (27) 15 plotted. (28) 9 plotted. (29) 13 plotted. (30) 26 plotted. (31) 23 plotted. (32) 4 plotted. (33) 10 plotted. (34) 22 plotted. (35) Leonids. Four observers under supervision of K. E. Gell. (36) Maximum definitely between 16:00 and 17:00 E.S.T. Nov. 15. (37) 12 plotted. (38) Observers Miller, S. J., McHugh, S. J., Perry, S. J., Diamond, S.J., Cohalon, S. J., Hayes, S. J. (39) Observers McHugh, S. J., Curry, S. J., Miller, S. J., R. Zegers, S. J. (40) Observers McPhelin, S. J., Murray, S. J. (41) Observers Miller, S. J., R. Zegers, S. J. (42) Observers McCarthy, S. J., McHugh, S. J. (43) Observers McPhelin, S. J., T. Zegers, S. J. (44) Count under Father Miller's supervision. Group of observers. (45) 2 plotted. (46) Count; number of observers? (47) Count by M. Sharnoff. (48) By J. D. Phenix; 2 plotted. (49) Count by

W. M. Browne. (50) By H. E. Burton and S. M. Bestul; 3 plotted. (51) Count by N. C. Seewald. (52) By B. P. Sharpless; plotted. (53) Count by F. P. Scott. (54) By N. S. Lyons; plotted. (55) Most plotted; group of observers. (56) Leonids, 22, plotted. (57) Leonids, 13, plotted. (58) 33 plotted. (59) 6 plotted. (60) 12 plotted. (61) 5 plotted. (62) 11 plotted. (63) 30 plotted. (64) 15 plotted. (65) Count by Mrs. Bunch. (66) 20 plotted. (67) Count of Leonids by group under leadership of Miss Nina Gamble. Maximum number of observers, 20. One observer plotted 3 on Nov. 14 and 14 on Nov. 15. (68) Brightest only; these plotted. (69) Three observers. (70) Four observers; plotted. (71) Count by one member of the Society. (72) Count by group of 19. (73) Count from airplane, route from Louisville, Ky., to Southern Pa.; reported to Louisville Astronomical Society. Maximum 14:00 to 15:00. (74) Count. Leonids only, during photographic work for trails. (75) Altitude and azimuth measured. Seven observers. (76) Altitude and azimuth measured. Nine observers. (77) Plots by Vern Scott, observing in group under Mr. Hales. (78) Transit observations; altitude and azimuth measured; four observers. (79) 18 plotted. (80) 48 plotted. (81) Count by Miss C. Wamer. (82) Three observers; 11 plotted. (83) Four observers; 5 plotted. (84) Four observers; 11 plotted. (85) Counts under the direction of L. E. Armfield. Observers at Milwaukee, Wauwatosa, Reedsburg. Reedsburg rates highest. (86) Leonids only. (87) Under the supervision of R. C. Huffer. (88) 8 plotted. (89) 17 plotted. (90) Incomplete counts while photographing. (91) Notes on each; approximate paths plotted for the 57 Leonids.

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1934 January 20.

Deaths Reported as from a Meteor

By C. C. WYLIE

The following newspaper item appeared in the *Japan Chronicle*. We are indebted to Mr. J. B. Penniston of the editorial staff of the *China Press* in Shanghai for the clipping. Mr. Penniston noticed this item and kindly sent it to us.

METEOR KILLS THREE.

Paris, July 5.

"A blazing meteor is believed to have caused the destruction by fire of a building in a village near Besancon. According to eye-witnesses the meteor struck the roof of the house, a loud detonation followed and flames burst out so suddenly that three occupants perished in them, while two others, who were forced to jump from a second story window, were seriously injured."

The item interested us because it reports two things for which as yet no report has been authenticated. First it reports that three people were killed, directly or indirectly, by the meteor. There is as yet no definitely authenticated report of death or injury which can be attributed to a meteor. Some earlier reports of supposed deaths by a meteorite were discussed in our Contribution No. 2, pages 68-70 (*P.A.*, **39**, 41). Another reason for investigating this newspaper item is the report that a meteor set fire to a building. There is no authenticated report of a meteor setting fire to anything.

Following the receipt of this newspaper item we wrote to Mr. R. Baillaud, Director of the National Observatory of Besancon. Mr. Baillaud kindly sent us a rather full report on the occurrence. The following is a translation of the main portion of his letter.

"A house has in fact been burned in the neighborhood of Ville Le Lac and several persons perished in the flames. The fire was discovered quite suddenly about thirty minutes after midnight. A customs officer

> on duty said that he saw a meteor (bolide) fall in the direction of the house in question two minutes before seeing the house burn. He added that he had seen a mass resembling a streak of fire fall on the house . . . I asked that a search be made in the ruins to find if possible some fragments of the aerolites. This was done as I requested but nothing could be found, which is not very surprising. The mystery remains for the moment complete in that respect and it does not seem likely that any certain proof can be obtained for the words of the officer. The officer was two kilometers from the house when he saw the meteor."

The assumption of the newspaper report is that the meteor struck the house as a ball of fire. Let us consider whether, in view of the evidence, that assumption is justified. Observation shows that the smaller meteors usually burn out at a height of more than fifty miles. In general, the brighter the meteor the lower it comes. Meteors which drop meteorites seem to burn out at a height of about 15 miles, on the average. The big Paragould meteor which dropped an 800-pound stone was luminous within five miles of the ground. For these meteors, the height at disappearance is established by personal interviews with a number of observers near the actual place of fall.

Observations indicate, as we have said, that the bigger a meteor the lower it comes. Hence, to reach the surface of the earth, a meteor should be bigger than those which disappear at five miles. But the meteors to which we have referred were bright enough to attract attention over several states. The detonations were also heard in several states. Near Paragould, the noise of the meteor frightened both men and animals.

Compare this light and noise with that of the Le Lac meteor. At Le Lac, there were presumably no detonations, and only one person saw the meteor. An officer saw the meteor fall in the direction of the house. He saw this from a distance of about 2 kilometers (a mile and a quarter), about two minutes before he noticed that the house was on fire. The fire was then so far advanced that three persons perished in the flames, and two others were forced to jump from the second story windows.

The Le Lac meteor seems to have attracted little attention. Even after the advertising because of the burning of the house, no additional reports were received either by the officials or at the observatory. From our experience with bright meteors in the United States we would say that the meteor probably did not come as low as thirty miles. A meteor which fell in Missouri and disappeared at a height of above thirty miles was sufficiently brilliant to cause the driver of a cross-country bus to stop. The interior of the bus was lighted up as though by a bright flash of lightning. Both driver and passengers wanted to see what had happened. So the driver stopped the bus, and he and the passengers got out and watched the trail of the meteor for a few minutes as it was disappearing. This meteor did not come low enough to cause any detonations but it aroused the interest of the public in four states. The Le Lac meteor attracted much less attention than this. It is very improbable that it came low enough to cause detonations, and it is almost certain that it did not come low enough to drop meteorites. As the meteor must have disappeared at a considerable height, the fact that the officer thought it struck a house only a mile and a quarter (2 kilometers) away shows that the meteor was at a considerable distance from Le Lac. Had it really been close, it would have disappeared quite high in the sky.

Such reports from people who see a distant meteor apparently fall behind a tree or a building are received with regularity. Most people who at first have this illusion learn later that the meteor must have been much farther away. They

see the meteor apparently fall on, or behind, something a short distance to the east, let us say, and they learn later that people living fifteen or twenty miles east of them also saw the meteor to the east. If they are intelligent people, they realize that it was the same meteor, and that the apparent closeness was merely an illusion. For a meteor which fell in Illinois on July 25, 1929, newspaper reports showed that some people in Milwaukee, Wisconsin, mistook the meteor for an airplane going down in flames. They thought it fell into Lake Michigan near them. Some people near Galesburg, Illinois, were sure that sparks from the same meteor struck a tree near Galesburg. A barber driving near Chariton, Iowa, saw the meteor apparently fall near him and picked up a stone which he was sure was the "star" which had fallen. A woman in Omaha, Nebraska, saw the meteor apparently fall into a tree, and reported that it burned off several limbs. When the great meteor fell near Amana, Iowa, in 1875, many people reported that they had seen buildings enveloped in flames and their first thought was that the buildings had actually been set on fire. A barn some one hundred miles from Amana did burn right after this meteor fell, and members of that family still believe that the meteor set the barn on fire.

In conclusion, it appears that the evidence for the meteor setting fire to the house in Ville Le Lac, France, in 1933 is no better than the evidence for the Illinois meteor of 1929 burning the tree in Nebraska. It is no better than the evidence for the Amana meteor of 1875 setting fire to a barn one hundred miles from where it fell. For almost any bright meteor, many observers believe, like the officer in Le Lac, that the ball of fire fell to, or almost to, the ground. But wherever there has been enough evidence to make possible an estimate of the real height at disappearance, it was found to be some miles above the ground.

University of Iowa, January 23, 1934.

Notes from the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD, President, and H. H. NININGER, Secretary

Two Successful Meteor Surveys Resulting in the Recovery of Meteorites

By H. H. NININGER

Since the great meteoric display of March 24, 1933, which was witnessed from seven States of the Southwest, the writer has been intermittently devoting much time to the problem of mapping accurately the visible course of the meteor through the atmosphere. Just as a rather lengthy paper had been completed, dealing with various phases of the phenomenon, and presenting several photographs and a map of the meteor's course, there came into his possession the first authentic specimens from this fall. The meteorite is of the stony (aërolitic) variety, very much like that of Nobleboro, Maine, which fell on August 7, 1823; it is very friable, and, as far as can be judged from the fragments at hand, it contains no metallic iron.

Before the survey of the March 24 fall had been completed, the fall of August 8 occurred in northwestern Nebraska, and considerable time and effort were devoted to a similar survey of the latter. Because it arrived in a country which was somewhat more thickly populated, the work on the Nebraska fall resulted in a more prompt recovery of a fragment, about the middle of August.

It is interesting to note that these two falls are almost identical in structure and composition—both resembling the Eucrites or Howardites rather than the more common variety of aërolites.

The March 24 fall arrived at 5:04 A.M., M.S.T., from 12½° N. of E. and descended at an angle of 8½° with the horizontal (measured at point of disappearance). It first came into view at an altitude of 78 miles and disappeared 17 miles above the ground. This describes only its general course for the meteor traveled in a spiral as was proven by a photograph taken by Chas. M. Brown, during its flight.

The August 8 meteor arrived at about 10:30 A.M., from a direction 15° east of south, and fell at an angle of about 25° to 30° with the horizontal, disappearing at an elevation of about 8 miles. A more complete account of this fall by the writer will appear at a later date. It is a source of satisfaction that both of these falls were successfully plotted by the method advocated in the August-September, 1933, number of this journal.*

An unexpected feature of the March 24 fall was that two of the fragments found had been dropped 35 miles before the end of the meteor's visible course. Another fragment was discovered 12 miles farther in the direction of the path, but still 23 miles back from the point of disappearance of the meteor. With the kindly coöperation of the ranchmen of the region, a systematic search is being made, in the hope that it will be possible to record exactly, the entire distribution of the fragments.

Recent Research Literature on Meteorites Received

Under the above heading will appear from time to time, as space will permit, a list of recent publications on meteorites, of a research or an original nature, which have been received at the Editors' office. No titles of date earlier than 1932 will be included, nor, for obvious reasons, will mention be made of any papers, *etc.*, which have appeared in POPULAR ASTRONOMY. It is hoped that these current bibliographies will prove useful for reference purposes to investigators and other students of meteorites, since most of the technical literature on this subject is widely scattered through diverse journals. Authors are requested to send in their publications to the editorial office of the Society, for enumeration if not for review in these *Notes*. A first, somewhat incomplete, list follows.

Chester R. Longwell: "Meteorite Scars," *The Geographical Review*, Vol. 23, No. 3, pp. 499-501, July, 1933.

H. H. Nininger and J. D. Figgins: "The Excavation of a Meteorite Crater Near Haviland, Kiowa County, Kansas," *Proceedings of the Colorado Museum of Natural History*, Vol. 12, No. 3, pp. 9-15 +3 pp. of illustrations and photographs, Nov., 1933.

"The Nininger Collection of Meteorites, with Descriptions of the Huizopa and Pojoaque Meteorites," issued by the Colorado Museum of Natural History, Denver, 1933: 20 pp.

C. A. Silberrad: "List of Indian Meteorites (with Plate 12)," *Mineralogical Magazine*, Vol. 23, No. 139, pp. 290-304, Dec., 1932.

L. J. Spencer, with chemical analyses by M. H. Hey: "A New Pallasite from Alice Springs, Central Australia (with Plate 4)," *Mineralogical Magazine*, Vol. 23, No. 136, pp. 38-42, March, 1932.

L. J. Spencer: "Origin of Tektites," *Nature*, Vol. 131, p. 117, Jan. 28, 1933.

L. J. Spencer: "Meteorite Craters as Topographical Features on the Earth's Surface," *The Geographical Journal*, Vol. 81, No. 3, pp. 227-248, March, 1933.

L. J. Spencer: "Two New Gem Stones," including "A Cosmic Gem?", *The Gemmologist*, Vol. 3, pp. 110-113, Nov., 1933.

Ralph W. Stone: "Meteorites found in Pennsylvania," *Topographic and Geologic Survey Bulletin* G2, Harrisburg, Pa., 1932: 28 pp.

*See H. H. Nininger: "What Constitutes Reliable Data Regarding Meteors or Fireballs?" *P.A.*, XLI (1933), pp. 367-70.

Miscellaneous Notes

Mr. Henry W. Nichols, Associate Curator of Geology of the Field Museum of Natural History, Chicago, Illinois, since 1924, and a Councilor of this Society, has been appointed Acting Curator of Geology of the Museum, in succession to the late Dr. Oliver C. Farrington, Curator from 1894 until the time of his death in November, 1933.

Mrs. H. H. Nininger, Secretary of the Nininger Laboratory, Denver, Colorado, has been appointed, on the nomination of the President of the Society, by the Executive Committee of the Council, to serve during the remainder of the current biennium, as the Assistant to the Secretary-Treasurer of the Society.

Secretary's Office: The Nininger Laboratory, 1955 Fairfax Street, Denver, Colorado.

Editors' Office: Department of Astronomy, University of California at Los Angeles.

A Correction

The writer's notice in the last issue of this Journal regarding the number of reported meteorites in the United States for 1933 included a reported fall near Ionia, Michigan, June 10. After the note was in press the supposed meteorite from this fall arrived in my office for inspection. It proved to be not a meteorite but a mass of terrestrial conglomerate.

It had been intended that the notes above referred to should not go to press until after the specimen had been examined; but through a misunderstanding the manuscript was sent in while the writer was engaged in field work in northern Mexico.

Both the Athens, Alabama, stone and that from Sioux County, Nebraska, had been examined by the writer and the South Carolina stone was listed on the authority of Stuart H. Perry, of Adrian, Michigan.

On December 23, the writer recovered four fragments from the great meteor of March 24 in New Mexico which brings the number of falls within the United States to four for the year even after eliminating the false report from Ionia.

The Society for Research on Meteorites invites reports from other parts of the world in order that it may be known whether 1933 has been an unusual year for meteorites in other countries.

The largest number of recorded falls for any year previous to 1933 was eleven in the year 1868. However, only two of these occurred in the United States.

H. H. Nininger, *Secretary-Treasurer,*
Society for Research on Meteorites.

Notes from Amateurs

Astrolab

Translations and Correspondence.

Those interested in Astrolab's coöperative work who would prefer to correspond in their own language should write in to us and we will put them in touch with one of our members who is familiar either with their or some language that is common to both.

The Astroscope.

Several contributors to Astrolab are skilled in the art of making sketches. There is good reason why the Astroscope, our mimeographed bulletin, should

contain plentiful sketches, charts, and drawings, provided some means of production on a comparatively large scale can be worked out. If you, who are interested in sending in sketches of designs, sky maps, and the like, will make them on tracing cloth or vellum, instead of ordinary stationery, we can make blue prints and submit copies to the committee members interested. The sketches should be 7½x9½ inches inside of border, or smaller, as this size fits our printing frame and one page of the Astroscope. RLB has sent in the first of these tracing sketches, a map of Orion, for the February Astroscope. Send some stamps for sample copy of the Astroscope, or for a blue print of RLB's "Orion" chart.

LENS MAKING.

One section of Astrolab membership has been devoting efforts to the production of lenses for astronomical development work. A pre-requisite for the making of a good optical surface is a smooth, beveled edge. A simple accurate method of beveling often used in optical shops, but not generally known to an amateur lens maker has been mimeographed, and a copy may be had for some stamps.

Each person developing his particular field of interest, wherein the parts fit into a planned whole is the Astrolab plan. Previous issues of POPULAR ASTRONOMY contain Astrolab progress reports.

If you would care to join your efforts to ours, please write to

L. I. BUTTLES.

10728 S. Artesian Avenue, Morgan Park, Chicago, Illinois.

Amateur Telescope Makers of Chicago

The Amateur Telescope Makers of Chicago held their monthly meeting in the Adler Planetarium and Astronomical Museum, Chicago, on Sunday, January 7.

Dr. M. M. States of the Central Scientific Company, Chicago, was the speaker. His subjects were the "Interferometer" and the "Resolving Power of the Telescope." He explained the formation of interference fringes and showed how a grating functions by the combined diffraction effects of a number of slits. An interesting discussion followed.

Leroy Clausing brought two samples of his work on evaporation. They were 8-inch flats, one coated with aluminum and one with aluminum and magnesium. They were beautifully done but he turned them over to the tender mercies of the members to see how much abuse they would stand. After much scrubbing, some of the film came off but it was demonstrated that with proper care an evaporated aluminum film will last for years, will not tarnish, and can be cleaned with soap and water when necessary.

The Zeiss polishing machine is being put to good use and two 10-inch Pyrex discs have been polished on it.

WM. CALLUM, *Secretary*.

1319 W. 78th Street, Chicago, Illinois.

Communication and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editors may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Note on the Sun's Heat

In POPULAR ASTRONOMY, Vol. XLI, March, 1933, there appears an interesting paper by Edward Godfrey, in which the theory is propounded that the sun's heat is due to the frictional effect of solar tides raised mainly by Jupiter. The variations of the solar constant from its mean value, as measured by the Smithsonian observers he assumes to be due to the comparatively smaller action of the remaining planets.

The main interest of the paper lies, to my mind, not in the theory actually proposed, which is physically untenable, but in an application of it to the problem of the variation of the solar constant. Before going on to a discussion of this extension of Godfrey's theory, I should like to point out the fundamental fallacy of his paper.

In the first instance, he discards the generally accepted theory that the solar heat is derived from the process of transmutation of mass into energy. It must be borne in mind that this transmutation in no way contradicts the law of conservation of energy, since, by Einstein's equation, matter and energy are commutable terms; in fact, matter of mass M possesses, by virtue of that mass, energy equal to $M \times c^2$, where c is the velocity of light. When, therefore, matter is converted into radiation, the amount of radiative energy set free is related to the mass lost by Einstein's equation, and the generalised law of conservation of energy still holds.

The reason for discarding the current theory was that there is no terrestrial analogy to the assumed process. This argument is hardly justifiable, as a consideration of the phenomenon of radioactivity will show. A lump of radium is radiating energy in the form of α, β, and γ rays, which energy is capable of keeping the temperature of the mass of radium permanently several degrees above that of its surroundings. A corresponding phenomenon on a very much larger scale on the sun is easily conceivable, and a constant rate of evolution of radiant energy on this basis assured.

A more serious objection to the tidal theory the author attempts to meet. To the obvious query as to the source of the energy which the sun, through the tidal action of Jupiter, is able to radiate, the author refers us to the "infinite source of the moving impinging ether, moving at the speed of light, the source of all energy." An appeal to this infinite source of energy, the mechanism of action of which is not explained, and the very existence of which is hypothetical, detracts seriously from the value of the paper. In fact, if the infinite source of energy is available to effect the solar radiation through the medium of the tidal action of Jupiter, the question arises why it is necessary for Jupiter to have come into the picture at all, and whether the ethereal energy might not as easily have been communicated directly to the sun as to Jupiter.

Apart, however, from the failure of Mr. Godfrey to prove his main thesis, his attempt is valuable since it points to a possible explanation of the variation of the solar constant. If the conclusions of the Smithsonian observers are accepted, the maxima of solar radiation intensity agree with the maxima of sunspot activity.

No theory of internal circulation has been framed to explain sunspots, though it is conceivable that such a theory might be drawn up to fit the facts. However, the concurrent variation in solar constant would probably involve more difficulty of explanation. We need not at this stage, postulate a knowledge of the exact solar mechanism by which the solar constant and the sunspot activity are linked. What is interesting is to note that Mr. Godfrey's tidal theory can be applied to the variations in the solar constant.

The planets all are responsible for tidal effects on the sun, the tide generating force depending on the mass of the planet and on its distance from the sun. Jupiter, on account of its great mass as compared with the other planets, causes the largest solar tides. When one or more of the planets act in conjunction with Jupiter, the resultant solar tides will be increased, and we will also have a variation in the height of the tide depending on the position of the planet concerned with reference to perihelion, and on the eccentricity of its orbit.

The tidal distortion of a gravitating mass of gas on these lines has not yet been investigated, but it might yield to analytical treatment, since in this case we have none of the boundary conditions which complicate tidal theory in the case of liquid contained between certain boundaries on the earth.

In the absence, however, of a detailed theory, it is not possible to state what the conditions are likely to be. Tidal distortion might, for example, bring niveaus of greater temperature than the normal photosphere to the surface, so that the total radiation emitted is that from a radiator slightly hotter than normal. (Note that if the sun radiates approximately as a black body, which is not far from the truth, a change in radiated energy of 6 per cent is equivalent to a change in photospheric temperature, assuming the area to remain constant, of 1½ per cent. At a temperature of about 6000°, this variation amounts to about 100°, which at the present stage of development of methods of temperature measurement could not be detected.)

It remains to be seen, from a quantitative study of the tides of the sun, whether the tidal forces available are sufficiently intense to cause the required distortion. If this mechanism is a possible one, we evade the difficulty of having to find a source of the excess energy radiated, since this energy comes from the sun itself, and the only loss that has to be made good by the planets is that due to friction, which has the well-known effect of increasing the semi-axis of the planetary orbit.

The tidal wave in the body of the sun, due to the sun's rotation with respect to the tidal protuberance must be expected to affect the internal constitution of the sun, and by frictional action to give rise to vortices, which may be shown by the appearance of sunspots. The differential sliding of the layers nearer to the solar equator over those nearer the poles, shown by the different rates of rotation at different latitudes, may be rendered unstable by the tidal motion, which would account for the observed rise and fall in sunspot activity. In this case, again, the planets merely act as a "trigger" to bring about the instability; the major part of the energy is supplied by the rotational energy of the sun.

At all events, the correlation observed between the tide-generating force and the variations of the solar constant and of sunspot activity is too marked and remarkable to be neglected. The theory here given is at best only a suggestion, and probably requires considerable modification. The observational material given by Mr. Godfrey, however, is my justification for putting it on record.

A. E. H. Bleksley.

University of the Witwatersrand, Johannesburg, South Africa.

Comments by Edward Godfrey

It is refreshing to see discussion of my theory such as that of Dr. Bleksley. Naturally my theory is not along the lines of that which scientists have generally accepted; also, as my paper merely touched on my theory of light and energy, it did not make clear its full bearing on the problem. Of course, my theory of light may be classed as hypothesis, just as all theories of light must be, and just as Einstein's theory of matter and energy. In my theory, radium, by its molecular

construction, merely transmutes the energy of the light-carrying particles that penetrate it into what we know as radiant energy. It does this on the earth, and other matter does not. This is where Einstein's hypothesis is totally lacking in confirmation.

It is surely a more sound hypothesis to assume that the source of the energy is in the wave-carrying particles penetrating all matter and space, already moving at the speed of light, than to assume that the enormous energy is bound up in "dead" matter ready to spring into terrific velocity, but held in check for no conceivable reason. The last sentence in my paper hints at the reason why the sun, without Jupiter, is not enough to catch the fugitive energy.

Tidal force, in my theory, is a tremendous thing, changing the shape of the entire body, not, as in the commonly accepted theory, a force that would merely lift the water of the ocean, for example.

Dr. Bleksley seems to concede that my theory offers an explanation for the variation of the sun's heat but not for its origin or up-keep. It is hard to separate the two in view of the constancy of the general average. He even seems to concede that sunspot upheavals may be explained by tidal motion of the superficial layers of the sun's substance in the torrid zones, so to speak. This is something not heretofore set up in any theory.

Professional Building, Pittsburgh, Pennsylvania.

The Sun-Jupiter Engine

Due to circumstances that have nothing to do with the gravitation of Jupiter, though they may in some way or another have a bearing on the heat of the sun, I did not have an opportunity to read the March number of POPULAR ASTRONOMY before the sun had entered the sign of Scorpio. And in late autumn a fellow does not think just the same as in the happy days of spring—not here about ten minutes of arc north of latitude 60 where I live anyway. When I read "The Sun's Heat" by Edward Godfrey (POP. ASTR., No. 3, March, 1933) the first snow of winter was falling in my frost-bitten garden.

That is probably why I sat down to consider seriously the distant heating plant of the only known abode of life in the solar system, the seething, hissing, and turbulent sun. Where did all that heat come from? Robert Mayer believed once that all that energy was supplied from the outside—from meteors falling into the solar atmosphere. According to Helmholtz the shrinkage of the sun under its own gravitational attraction was the source of the energy in the sun. These explanations have been abandoned long ago, however, and it seems like neither chemical action in general nor radioactivity can provide for all the energy radiated by the sun up through the ages. The theory of the formation of heavy atoms out of simpler ones as the source of energy in the sun accounts for a lot of heat, but is open to certain objections. And as to the total annihilation of matter as the source of energy in the sun, that too is as yet an open question. And to all this comes now the Godfrey theory: "The sun's heat is due primarily and almost solely to the presence of the giant planet Jupiter in our system. Without this planet in the system the sun would emit so little heat that all life on our planet would soon become extinct."

How about Jupiter, does that planet not recede from the sun? Yes, according to my own system of planetary progression (POP. ASTR., No. 9, Nov., 1930, p. 566) Jupiter has increased its mean distance from 642.1 to 777.8 mill. km. And the planetary progression system of Mr. H. L. Spahr (POP. ASTR., No. 7, 1930, and No. 6, 1933) indicates a still larger recession from the sun, namely 0.967 astr.

units or 144.5 mill. km. How would the temperature of the sun have behaved if the indicated outward movement of Jupiter was regarded as real and Jupiter regarded as the source of the heat supply in the sun? Would such a consideration not kill this startling theory that gives to Jupiter the honor of sustaining life on earth?

No, it does not seem so. It rather confirms the theory that the sun has once been as hot as 9000 degrees Celsius. For if that much heat was stirred up in the sun by the planet Jupiter and this source of supply had receded the indicated distance, then there would by now be about 0.66 of the original heat left, that is, the surface temperature of the sun should now be 6000 degrees Celsius or a little less, which is close enough to the generally accepted value.

So this queer theory of Jupiter as the *sine qua non* of the habitability of the earth has evidently to be met with some other argument. How about the Earth-Moon engine, would not such an engine based on the same principles as the Sun-Jupiter engine heat the earth to incandescence?

No, it would not. While Jupiter pulls the sun about 740,000 km away from its center, the earth is pulled only about 4650 km off center by the moon. And the resulting gravitational force at work in the two cases is of the order of 1:2000. The heat produced on the earth's surface by the gravitation of the moon will certainly not kill anyone in summer-time, to say nothing of the modification effect of northern winter temperatures. If there be anything in this theory of gravitational heat at all, then the heat caused by the earth pulling the sun about 450 km off center would result in more comfort than the heat produced by the Earth-Moon engine.

But if Jupiter is responsible for the sun's heat, why is not that planet caused to blaze up into a flaming body by the gravitational stresses supposed to generate such a lot of heat? And if Jupiter once was a sun and the large moons warm and lighted planets, why did not the Jupiter-sun continue to receive incandescent heat from the original outside source? Probably because small suns like Jupiter and Saturn burn out in the same way the large suns do, when the stuff in the suns generating the internal heat that moves to the surface and radiates into space is exhausted. Some day the ever-searching scientists may find out with some certainty how the sun-engines work and forget how the Sun-Jupiter engine once upon a time was supposed to work.

Or do you believe in the Sun-Jupiter engine? I don't.

HANS A. ERIKSEN.

Kreftings gt. 5, Hønefoss, Norway, November 10, 1933.

Zodiacal Light Notes

By FRANKLIN W. SMITH

The morning Zodiacal Light was observed on December 22, from 5:10 to 6:00 E.S.T. The apex was just south of η Virginis. The northern boundary passed just north of β Librae, while the southern was about 5° south of α Librae and perhaps 1° south of Spica. The elongation of the apparent apex from the sun was therefore about 86°, and the axis of the light cone was about 3° north of the ecliptic. This apparent northward shift is probably due to the increased absorption of light at the southern edge of the cone as it moves southward along the ecliptic.

The evening Zodiacal Light was observed from 6:45 to 7:15 on January 10.

The apex was near o Piscium. The northern edge passed north of θ Piscium and south of θ Pegasi. The southern edge passed near ι Piscium and Fomalhaut. These observations place the apex at an elongation of about 93°, and indicate that the axis fell just about on the ecliptic.

The brightness of the light at points on the ecliptic and 51°, 66°, and 77°, respectively, from the sun, was compared with the brightness of the sky background by means of the surface photometer. It was found to be respectively 1.46, 1.24, and 1.05 times that of the background at these three points.

407 Scott Avenue, Glenolden, Pennsylvania, January 17, 1934.

General Notes

Professor R. S. Dugan, of the Princeton Observatory and secretary of the American Astronomical Society, has been granted a sabbatical leave of absence for the current semester. He and his family are spending this period in Pasadena.

Dr. C. C. Wylie, of the University of Iowa, has been granted two hundred and fifty dollars from the J. Lawrence Smith Fund of the National Academy of Sciences. Dr. Wylie will use this sum principally in developing equipment for measuring the velocity of meteors.

Dr. Harlow Shapley, director of the Harvard College Observatory, was awarded the Rumford Medal of the American Academy of Arts and Sciences at a joint meeting of the Academy and the American Association for the Advancement of Science in Boston on December 27. On this occasion Dr. Shapley delivered an address on the subject, "The Anatomy of a Disordered Universe."

Miss Maude Bennot, Assistant Director of the Adler Planetarium and Astronomical Museum, returned from Europe on December 24, 1933, and immediately resumed her duties. While abroad she visited Planetaria in Jena, Berlin, Hamburg, Stockholm, Milan, and Rome; observatories at Hamburg, Neubabelsberg, Copenhagen, Stockholm, Oslo, Greenwich, Oxford, Paris, Milan, and Florence; the Museum of Science at South Kensington, the Ashmolean Museum at Oxford, Conservatoire des Arts et Metiers and the Cluny Musee in Paris, Tribuna di Galileo in Florence; and viewed the private collections of scientific instruments of Dr. R. S. Clay and Dr. R. S. Whipple in London, and of Georges Prin in Paris.

Dr. Josef J. Johnson writes from Tokyo under date of January 12, as follows: "The 'American Colony' at the eclipse camp in the Caroline Islands (either Losap or Oroluk) on February 13 is to consist of two persons, Dr. Willi M. Cohn and myself. Dr. Cohn is taking along a polarigraphic camera and several other small cameras. He is trying to borrow a spectrograph from Tokyo University. My own work is to consist in visual measurements of coronal polarization.

"A dozen or so observers are going from Tokyo, among whom will be Dr. Kiyofusa Saotome (Einstein effect), Mr. Yoshio Fujita (spectroscopy), Mr. Kazuo Kubokawa (direct photography), and Mr. Saburo Nakano (latitude and longitude). Commander Akiyosi, of the Naval Hydrographic Office, is to make measurements of the earth's magnetic field. Lt. Cmdr. Ito, of the National Research Institute, is in charge of the radio work.

"Drs. Ueda and Araki are coming from Kyoto."

The Chicago Astronomical Society held a meeting at the Adler Planetarium and Astronomical Museum on January 26, 1934. At this meeting an illustrated address by Professor Robert H. Baker, of the University of Illinois, was given, his subject being "Galaxies."

The Rittenhouse Astronomical Society of Philadelphia held its monthly meeting in the hall of The Franklin Institute, Twentieth Street and the Parkway, Tuesday evening, January 16. The program consisted of an illustrated lecture on "Comets" by Dr. Charles P. Olivier, Director of the Flower Observatory, University of Pennsylvania.

The McDonald Observatory Telescope.—The 81-inch disc for the principal mirror of the McDonald Observatory telescope was successfully poured on Sunday, December 31, 1933, at the Corning Glass Works, Corning, New York. This is not the largest piece of glass ever made because the Corning Glass Works have already completed a disc of 120 inches in diameter, which is to be used in connection with the California 200-inch telescope. The 100-inch of Mt. Wilson also exceeds it in size. However, it is probable that the McDonald mirror is the third largest piece of glass ever made.

Max Wolf (1863-1932), Ein Gedenkblatt, is the title of a twenty-eight page pamphlet containing the addresses given at a memorial service for Professor Max Wolf. This service was held on June 26, 1933, in the great hall of Heidelberg University and was participated in by the members of the University, citizens of Heidelberg, and friends and former students of Professor Wolf's from far and near. The principal address was given by Professor Kopff, director of the Rechen-Institut, for many years associated with Professor Wolf in astronomical research. His address gives an appreciative and sympathetic account of the personality and the accomplishments of Professor Wolf. At the conclusion he quotes the philosophy of life which characterized Professor Wolf as follows: "I live my life in widening circles, encompassing more and more. I shall probably not complete the final one, but I will attempt it."

The Annie J. Cannon Prize in Astronomy

A prize of one thousand dollars received by Dr. Cannon from the Association to Aid Scientific Work by Women has been accepted by the American Astronomical Society as an endowment for the award of a prize to women for research in astronomy. The rules for the award are given below.

The thoughtfulness and enthusiasm expressed by this gift are characteristic of the donor, and the recipients of the prize will value it mainly because it comes from her.

1. The prize is to be designated as the Annie J. Cannon Prize in Astronomy.
2. It shall be awarded to women for distinguished contributions to astronomy or for similar contributions in related sciences which have immediate application to astronomy.
3. The prize shall be open to women of all countries.
4. The award shall be by the Council of the American Astronomical Society and shall be announced at the December meetings of the Society.
5. The award shall be first made in December, 1934, and thereafter at intervals of three years subject to the judgment of the Council. The award may be omitted at any time at the discretion of the Council.
6. The prize shall consist of a token or certificate and of a money award

determined by the Council. Only the accumulated interest shall be used for the prize, the principal fund remaining intact.

7. The American Astronomical Society shall be the custodian of the fund which shall be invested by the Treasurer of the Society on the advice of the Finance Committee.

R. S. DUGAN, *Secretary.*

Glass Made for McDonald Observatory Mirror

A huge pancake of glass, more than a foot in thickness, nearly seven feet in diameter and weighing 5,600 pounds, is being cooled slowly at the rate of two to four degrees a day. This cooling process will continue for more than three months. At the end of that time the glass pancake will be the raw material for the 80-inch mirror in the reflector telescope being built by the Warner & Swasey Co., Cleveland, for the McDonald Observatory of the University of Texas, for which the company has the contract.

The mirror was recently poured by the Corning Glass Works, Corning, N. Y., in the presence of company officials, Dr. Otto Struve, director of Yerkes Observatory and the new McDonald Observatory, and E. P. Burrell, director of engineering for the Warner & Swasey Co.

After the mirror is entirely cooled, it will be carefully packed and crated and shipped to the Cleveland plant of the Warner & Swasey Co. for grinding. Machinery for this is now being set up.

The grinding of such an enormous mirror, exceeded only in the entire world by the 100-inch reflector at Mt. Wilson, is a long and tedious process. With good luck, it may take only a year. If all conditions are not perfect, it will take as much as two years, according to Mr. Burrell.

As the mirror takes form, the grinding time will be reduced until it reaches only 15 minutes a day. This is necessary to allow the mirror to cool thoroughly from the heat created by the grinding.

When the mirror is completed, it will measure 80 inches in diameter, 12 inches in thickness and will have a concave upper surface one and a quarter inches deep. Through the center will be a hole 13½ inches in diameter for the passage of light rays.

The mirror is made of a special glass, somewhat like that used in making cooking dishes, except that it is of a finer quality and absolutely clear.

With the aid of the reflector telescope, of which this mirror will be a part, scientists will be able to observe stars a million times fainter than the faintest star now visible to the naked eye.

The observatory which the Warner & Swasey Co. is now building is located on Mt. Locke in the Davis Mts. in Texas. It will be operated jointly by the University of Texas and the University of Chicago.

The Warner & Swasey Co., internationally known as builders of machine tools and precision instruments, has designed and built some of the most famous observatories in the world. These include the 36-inch Lick telescope in California, the 40-inch Yerkes telescope of the University of Chicago, the 69-inch Perkins telescope at Ohio Wesleyan University, and the 72-inch reflector telescope of the Dominion Observatory in Victoria, B. C.

Boyden Observatory.—Some 200 people, including leading citizens in all walks of life, attended the official opening of the Boyden Station of the Harvard Observatory at Mazelspoort about sixteen miles from Bloemfontein, when they were afforded an opportunity of inspecting the buildings and equipment of one of

the world's most modern observing institutions.

The Mayor of Bloemfontein (Mr. J. B. Dersley), in his opening address, mentioned that the station was equipped with six telescopes recently put into commission. They include one of 60 inches clear diameter and are the most powerful instruments south of the equator.

Dr. J. S. Paraskevopoulos (Director of Boyden Station) told how the observatory came to be established in Bloemfontein. There would be further developments in future both as regards building and staff, the latter already including three Afrikaans-speaking South Africans and one English-speaking.—REUTER. *Cape Times.*

Bloemfontein, November 30, 1933.

Book Review

Handbuch der Astrophysik, Vol. V, First half. Edited by G. Eberhard, A. Kohlschütter, H. Ludendorff. (Julius Springer, Publisher, Berlin, Germany. 96 marks; bound 99 marks.)

This part of the extended work, which is to include six large volumes when finished, appeared in the latter part of the year 1932. It consists of 574 pages, with 173 illustrations. The contents include contributions from four internationally known astronomers.

Pages 1 to 107 contain a paper by the late Professor R. H. Curtiss on the topic "Classification and Description of Stellar Spectra"; pages 109 to 125, a paper by Dr. Fr. Becker, Bonn, on a topic relating to the statistics of spectral types; pages 128 to 205, a paper by Professor A. Brill, Neubabelsberg, on the temperature of the fixed stars; and pages 210 to 574, a paper by Professor Knut Lundmark, Lund, on "Luminosities, Colours, Diameters, Densities, Masses of the Stars." The first and last of these are in English, the other two, in German.

The paper by Professor Curtiss, aside from its intrinsic value, is of exceptional interest to American students and astronomers because of the high regard in which Professor Curtiss was held by his colleagues and friends. This paper was completed only a short time before his seemingly untimely death on December 25, 1929. It is done with exceptional thoroughness and one can use the facts with great assurance of their accuracy. This, indeed, may be said of all of these papers, and of all in the entire series.

The volume is entirely too inclusive to permit the mentioning of details. The fourth paper fills more than half of this part and is to be continued into the second half. Professor Lundmark begins his discussion with the earliest known considerations relating to the brightness of the stars, and traces the development of this phase of astronomical investigation. Because of its extent and completeness it affords a compendium of great value in this field.

As one notes the scope of this work as a whole and the names of those contributing to it, he feels sure that *Handbuch der Astrophysik* will be a standard reference work in astronomy for generations to come.